STRATIGRAPHY OF THE JURASSIC AND LOWER CRETACEOUS ROCKS AND JURASSIC AMMONITES FROM NORTHERN AREAS OF WEST PAKISTAN

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CONTENTS

ABSTRACT

The stratigraphy of the Jurassic and Lower Cretaceous formations and Jurassic ammonites from Hazara, Kala Chitta, Nizampur, Western Kohat (Samana Range) and the Trans Indus Ranges in Northern Pakistan are described.

A provisional zonal scheme is proposed and correlation is suggested with Spiti, Cutch, Mada-

gascar, Mediterranean Province, Middle East, and East Africa. Failure to recognize certain ammonite zones in the area may be explained by non-deposition, slow deposition, unfavourable facies, failure of collection or some combination of these factors.

Middle Callovian, Upper Oxfordian and Lower Kimmeridgian ammonites from the Trans Indus Range, Upper Oxfordian–Tithonian ammonites from Nizampur, Lower Toarcian ammonites from Kala Chitta and Lower Tithonian ammonites from northern areas of Hazara are recorded and described for the first time. In addition, a definite Aptian ammonite fauna is recognized in parts of Western Kohat and the Kala Chitta Range.

The faunal studies indicate that the Jurassic passes into the Cretaceous without a break in most areas of northern West Pakistan. The major stratigraphical breaks are Pre-Toarcian, Intra-Jurassic (pre-Upper Oxfordian, pre-Kimmeridgian or pre-Tithonian) and intra-Cretaceous (post-Lower–Middle Albian).

I. INTRODUCTION

EXISTING knowledge of the Jurassic–Cretaceous biostratigraphy in general, and of the ammonite faunas in particular, of the northern areas of Pakistan (fig. 1) is very imperfect. In the majority of cases the faunal descriptions are based on collections which lack adequate biostratigraphical control. The geological information available in more recent published literature (Davies 1930; Cotter 1933; Spath 1930, 1934, 1939; Arkell 1956; Pascoe 1959; Krishnan 1960), though it gives the impression of the presence in the area of various Jurassic–Cretaceous stages, does not clearly relate them to the rock succession and little attempt has been made to correlate them in different parts of the country.

This state of confusion may be judged by the following remarks of Arkell (1956: 393) on the Jurassic rocks of the Salt Range, "Very little palaeontological classification of these (Jurassic) rocks is yet possible, though ammonites occur. Callovian is indicated by Golden Oolite . . . . It was also found in working the fauna of the condensed and transgressive Valanginian beds that they contain a number of derived Upper Jurassic ammonite fragments which indicate the former presence of Middle Spiti Shales. Old records by Oppel of ammonites . . . suggest the presence of Upper Oxfordian also". Spath similarly (1939; 131, 152) recognized Callovian and Tithonian ammonite fragments from the Salt Range and its Trans Indus extension, but considered the Tithonian fauna to be derived, and doubtfully pointed out the Callovian ammonites to have come from the limestone below the "Belemnite Beds".

Encouraged by the known occurrences of ammonites in the area, a detailed study of selected Jurassic and Lower Cretaceous sections in northern Pakistan (figs 1, 3) was carried out during 1963–1966. In this paper the biostratigraphy of the Jurassic and Lower Cretaceous rocks and the systematic descriptions of Jurassic ammonites from Hazara, Kala Chitta, Nizampur, Samana Range (Western Kohat) and Trans Indus Ranges are presented. A tentative correlation of the various Jurassic and Cretaceous formations of northern West Pakistan is also offered. This work forms part of a Ph.D. thesis submitted to the University of Wales in 1968. The ammonites of Lower Cretaceous age will be described in a separate publication.

The Mesozoic rocks of northern West Pakistan (figs 2, 3) are exposed in the hill ranges bordering the Kohat district to the north (Samana and adjoining ranges) and extending eastward into Nizampur and the Kala Chitta Range. Further east of

Kala Chitta the outcrops take a north easterly swing and are exposed in Hazara Ranges (Margala and Murree Hills) lying between Abbottabad and Islamabad. These northerly placed Mesozoic out-crops are separated by a belt of Tertiary and Quarternary deposits from the southern outcrops of Western Salt Range and Trans Indus Ranges (Surghar, Maidan and Khisor Ranges including Shaikh Budin Hills). In the eastern and north-eastern limits the Mesozoic rocks of northern areas are separated from that of Himalaya (Spiti) by a belt of Tertiary and Quarternary

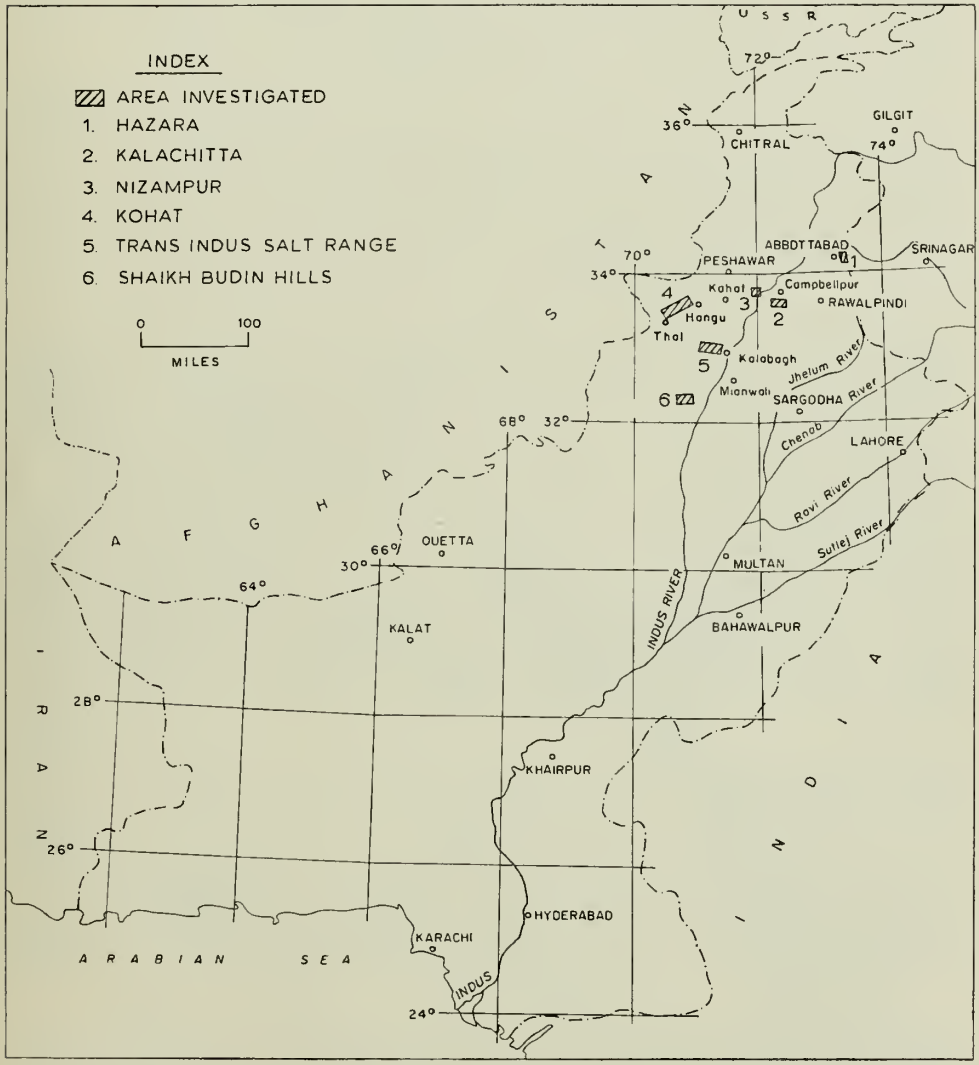

FIG. 1. Index map of West Pakistan showing areas investigated.

deposits while in the western limits the Tertiary and Quarternary deposits of D.I. Khan district separate it from the Mesozoics of Sulaiman Range and its northerly extension is Waziristan and Kurram Agency.

The area investigated falls between Lat. 32° N and 34° 30′ N and Long. 71° E and 73° 30′ E. Bordering it in the north are the high Karakoram-Hindukash mountain ranges with a complex geological history and with rocks belonging to a complex igneous and metamorphic suite of doubtful Precambrian to Tertiary age. On the southern boundary of the area, the Salt Range and Trans Indus Ranges with Precambrian to Tertiary rocks give place to the alluvial plain of River Indus through which protrudes near Chiniot and Shahkot (Kerana Hills), the reminiscent of the Precambrian metamorphic rocks of the Indian Shield.

The majority of the ammonites are preserved as internal moulds in a ferruginous, phosphatic, glauconitic, sandy, calcareous matrix, and much less commonly they have recrystallised or original shell matter preserved. The Callovian and Lower Jurassic ammonites are preserved in limestone. The Lower Jurassic (Toarcian) ammonites have abundant comminuted molluscan debris, are often fragmentary, and are unevenly distributed along the outcrop. The Callovian ammonites are better preserved and more complete.

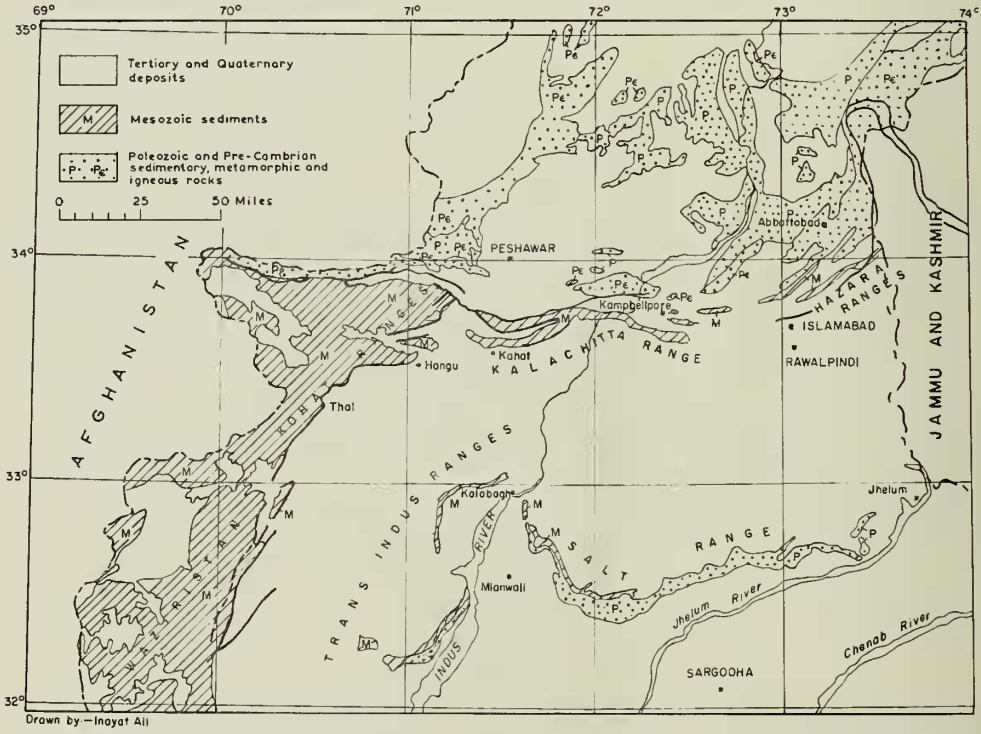

FIG. 2. Geological map of parts of West Pakistan showing Mesozoic outcrops.

The Upper Oxfordian ammonites occur in condensed sandy, glauconitic, nodular marls (less than a foot in thickness) at the base of the Chichali Formation. They are commonly fragmentary and worn, though abundant, in certain parts of the outcrop, but irregular in their distribution. The specimens from the Trans Indus Ranges show a better preservation than those from the Kala Chitta and Nizampur (Mazari Tang). The ammonites are associated with bivalves, gastropods, brachiopods and belemnites.

The Lower Kimmeridgian ammonites are preserved in calcareous, ferruginous, phosphatic nodules and are not very common. They are located in the lower 10 to 15 feet of the Chichali Formation ("Belemnite beds") in the Trans Indus Ranges and in the basal 2 to 3 feet of the Chichali Formation (= "Spiti Shales") in parts of Hazara and Kala Chitta.

The Tithonian ammonites are more commonly distributed in the succeeding beds of the lower member of the Chichali Formation in the Trans Indus Ranges. In parts of Hazara they occur in the basal part of the Lumshiwal Formation (="Giumal sandstone") and show better preservation than that of the Trans Indus Ranges. Associated with ammonites are abundant belemnites, less commonly bivalves (*Trigonia* sp., *Gryphaea* sp.), brachiopods and reptilian remains.

This paper presents the results of the research work on Mesozoic Stratigraphy and Palaeontology of northern areas of West Pakistan carried out for a Ph.D. thesis at the University College, Swansea, University of Wales during 1967–68. Many colleagues and friends in and outside Pakistan have been of great assistance in providing helpful suggestions and criticisms. I am particularly indebted to Prof. F. H. T. Rhodes and Dr. J. C. W. Cope of University College, Swansea for their supervision, guidance and critical review of the work. For this paper I am deeply indebted to Dr M. K. Howarth who guided me in its presentation and has critically reviewed the fauna. Assistance of Dr. M. K. Howarth and the staff of the British Museum in reorganizing some of the illustrations and re-photographing the specimens for presentation in this paper is gratefully acknowledged. Special thanks are due to Dr J. H. Callomon of University College, London for his helpful criticism of the research work. Dr R. Casey, Mr N. J. Morris and Prof. D. V. Ager are thanked for their guidance and identification of some ammonites, bivalves and brachiopods respectively.

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The systematic descriptions mostly carry the standard morphological terms as defined in the Treatise on Invertebrate Palaeontology (1957: (L) Mollusca-4). The standard dimensions (diameter, whorl height, whorl thickness, umbilical diameter) are given in millimeters and as percentage of diameter. The measurements were made over the ornamentation unless specified in the text.

II. HISTORY OF PREVIOUS RESEARCH

The presence of Jurassic and Cretaceous rocks in northern West Pakistan was first recognized in the late 19th century (Waagen 1875; Wynne 1878; 1880, Griesbach

1891; Middlemiss 1896), but it was many years later that a more detailed Mesozoic succession was established by the field studies of Davies (1930) in the Samana Range, Cotter (1933) in the Kala Chitta Range, Spath (1939) and Gee (1945) in the Salt Range and its Trans Indus extension (Trans Indus Ranges).

The ammonite collections of Gee, Cotter, Davies and such other workers as Wynne and Fleming were described by Spath in a series of monographs (1930, 1934, 1939).

Spath based his palaeontological conclusions on the stratigraphical information provided by other workers. His interpretation of the fauna, though fairly accurate, lacks in many instances a proper biostratigraphical control. Four of his observations, mentioned below, have been found to require reassessment in the light of the present work.

1. Spath and others (Arkell, Pascoe, Krishnan) suggested a break in sedimentation at the Jurassic–Cretaceous boundary. Although Spath mentioned Upper Jurassic ammonites in the basal "Belemnite Beds", he considered them to be derived. The present study shows that there is no break of sedimentation at the Jurassic–Cretaceous boundary.

2. Spath (1930 : 65–66) suggested the absence of Aptian transgression (which reached Persia and Cutch) from most of the areas of northern West Pakistan. The present discovery of Aptian ammonites in Kohat-Nizampur area indicates sea connections with Cutch and Persia via Baluchistan in at least the western half of the area examined.

3. Spath (1939 : 132) believed the lowermost Neocomian (Berriasian and Lower Valanginian) to be absent in the main Salt Range (implying the western part) and the Tithonian and rest of the Upper Jurassic down to Callovain to be absent from the Trans Indus Ranges. In the present study, it was found that Berriasian and Lower Valanginian ammonites occur in the western Salt Range and that a definite Upper Oxfordian–Lower Kimmeridgian–Tithonian and Berriasian succession is present in the Trans Indus Ranges.

4. Spath (1939 : 131) postulated the continuity of "Spiti Shale" facies of Spiti, Himalaya in the Hazara, Kala Chitta, Waziristan and Baluchistan regions and the subsequent denudation and erosion of the Upper Jurassic sediments prior to Berriasian transgression. The present study indicates that the Upper Oxfordian–Lower Kimmeridgian transgression connected Cutch with Spiti through parts of the area under discussion. The major transgression, however, took place in the Tithonian and effected all the area extending to Baluchistan in the west.

The more important contributions to the Mesozoic stratigraphy and palaeontology of individual areas may be summarized as follows:

Hazara. Rather fragmentary information exists in literature on the area (Waagen and Wynne 1872; Middlemiss 1896; Wadia 1926; Arkell 1956; Pascoe 1959; Krishnan 1960). Waagen and Wynne and later Middlemiss recognized the following Himalayan (Spiti) succession:

3.	"Giumal Sandstone"	Cretaceous
2.	"Spiti Shales"	Jurassic
1.	"Kioto Limestone"	Mainly Triassic

The "Kioto Limestone" of Hazara is the most confusing unit being relatively

poor in ammonites and other well-preserved fossils. It has been referred to the Upper Triassic by Middlemiss (1896), Wadia (1926 : 155), Pascoe (1959 : 897) and to the Upper Triassic–Lower Jurassic by Cotter (1933), Arkell (1956) and Krishnan (1960). The Upper Triassic age was suggested on the reported occurrence of fragmentary mollusca, identified as *Megalodon, Dicerocardium, Chemnitzia* (Pascoe: 898). More recently Davies and Gardezi (1965) recorded *Bouleiceras* (identified by Dr Howarth of the British Museum) of Lower Jurassic age (Lower Toarcian) from the lower part of the "Kioto Limestone" in parts of Hazara (Bagnotar).

The "Spiti Shales" in Hazara are reported to contain *Belemnopsis gerardi* (Oppel) and *Virgatosphinctes frequens* (Oppel).

Spath (1933 : 804) recorded the Berriasian ammonites *Neocosmocarms octagonides* (Uhlig) and *Neocosmoceras subradiatus* (Uhlig) from Murree Hills in Hazara and correctly thought them to have come from below the Albian ammonite beds and above the *Virgatosphinctes frequens* (Oppel) horizon in the Guimal Sandstone (Pascoe 1959 : 1186) near Kathwal. A similar Lower Tithonian ammonite fauna from this area is described here.

From the upper part of the "Giumal Sandstone" Spath (1930) described Middle Albian ammonites such as *Lyelliceras lyelli* (d'Orbigny), *Douvilleiceras* aff. *monile* (J. Sowerby), and *Oxytropidoceras* aff. *roissyanum* (d'Orbigny). He correlated the Hazara Albian ammonite bed with that of Kala Chitta and Kohat (Samana Range) and pointed out the abundance of *Lyelliceras* in Hazara and that of *Douvilleiceras* in the Samana Range.

Middlemiss (1896) and Wadia (1926) compared the Jurassic rocks of northern Hazara with the "Spiti Shales" of Himalaya (Spiti) and the more arenaceous facies of southern Hazara with the Jurassic of the Salt Range. It is, however, not evident which arenaceous rocks they implied in the correlation.

Kala Chitta Range. Cotter (1933) carried out the first detailed survey of the Kala Chitta Range. His fossil collections were studied and monographed by Spath (1934—Cephalopoda), Cox (1935—Bivalves and Gastropoda) and Muir Wood (1937—Brachiopoda). Cotter recognized the following Mesozoic succession.

"Shales north of Kawaghar".		(uncertain age ? Palaeocene)
"Giumal" limestone, sandstone and sandy limestone	} Undifferentiated .	Upper Oxfordian to Albian
"Kiota Limestone"		Upper Triassic to Liassic.

Cox (1935) identified *Indopecten* sp. of Upper Triassic age and *Lima gigantea* (Sowerby), *Eopecten velata* (Goldfuss), *Plicatula spinosa* (Schloth) of Lower Jurassic age from the "Kioto Limestone, but no precise stratigraphic position of these fossils was given. He further identified the Middle Jurassic bivalves *Corbula lyrata* (Sowerby), *Protocardia grandidieri* (Newton), *Eomiodon indicus* Cox from the gray rubbly limestone, and placed them doubtfully in the upper part of the "Kioto Limestone". Cox compared the fauna with the Kuar Bet Beds of Cutch and regarded it as Bajocian, but with the reassessment of the fauna of Kuar Bet Beds the age of the beds was changed to Upper Bathonian (Arkell 1956 : 391, 400).

Spath (1933 : 803) briefly mentioned some Lower Triassic ammonites submitted to him in Wynne's Punjab collections from "Central Kala Chitta Pahar" (Kala Chitta Range), but without any precise location or stratigraphic position. In the present work the stratigraphy of the "Kioto Limestone" is redefined on the basis of newly found fossil horizons and changes in lithology. The limestone is divided into five distinct formations. The lower three Triassic formations are separated with a marked disconformity from the overlying Lower and Middle Jurassic formations.

From the ammonite collections of Cotter marked "basal Giumal", Spath (1934) identified a typical Upper Oxfordian (Transverserium Zone) and Tithonian assemblage including species of *Perisphinctes*, *Mayaites polyphemus* (Waagen), *Blanfordiceras*, *Aulacosphinctes*, *Himalayites* etc. Cox (1935) identified *Exoygra fourtaui* Stefanini, *Gryphaea balli* (Stefanini) and *Ctenostreon proboscideum* (J. Sowerby). Although he assigned an Upper Oxfordian age to the assemblage, he mentioned rightly that *Gryphaea balli* is abundantly distributed in the basal Kimmeridgian of British Somaliland, and the present study shows that this species occurs in beds of Lower Kimmeridgian and younger age.

From the upper part of "Giumal" Spath identified *Oxytropidoceras* and Cox *Neithea attockensis* Cox, *Exogyra arduennensis* (d'Orbigny) and assigned a Middle Albian age. Cox also identified *Trigonia ventricosa* Krauss from the "Giumal Sandstone" and assigned a Neocomian age.

Summarizing the geological information on the Attock district (Kala Chitta Range), Arkell (1956 : 400) stated "the Spiti Shales in turn are overlapped by Giumal Sandstone, which takes on a shelly facies and incorporates at the base, or rests on condensed representatives of, certain Oxfordian horizons which belong low down in the Spiti Shales". Similar views were expressed by Cotter (1933) who contended that the "Spiti Shales" may not have been deposited in the area. The present study indicates that the "Spiti Shales" and the "Giumal Sandstone" renamed in accordance with the Stratigraphic Code of Pakistan as the Chichali and Lumshiwal Formations respectively are distinct and recognizable units which show lateral variations in lithology and thickness, but are persistent in the area investigated.

Nizampur. Excepting for some general remarks regarding the presence of Jurassic and Cretaceous rocks (Griesbach 1891; Pascoe 1959 : 1314, 1169) there is no published information on the fauna of this area.

Kohat district. L. M. Davies (1930) was the first to define the Mesozoic succession in the Samana Range and assign more precise ages based on his own observations and identification of the fossils by Cox (1930—gastropods and bivalves), Muir-Wood (1930—brachiopods), Currie (1930—echinoids) and Spath (1930—ammonites). Davies established the following sequence in the Samana Range.

7.	"Upper Lithographic Limestone"	Upper Cretaceous
6.	"Variegated Series"	
5.	"Lower Lithographic Limestone"	
4.	"Main Sandstone Series"	Lower Cretaceous
3.	"Belemnite Bed"	Neocomian
2.	Samana Suk Limestone	Uppet Jurassic
1.	"Lowest Samana Beds"	Lower-Middle Jurassic

From the upper part of Unit 1 Muir-Wood identified *Rhynchonelloidea arcuta* (Quenstedt) and the horizon was assigned a probable Upper Bathonian and possible Lower Callovian age.

From the upper part of the Samana Suk Limestone (Unit 2) Davies recorded traces of ammonites, belemnites and fragmentary crinoids (*Pentacrinus* sp.) and considered the age to be Upper Jurassic.

From Unit 3 ("Belemnite Bed") Davies reported abundant belemnites, but no ammonites from the Samana Range. He did collect one ammonite from the Khadimakh hill (Kadamak of Davies), which was identified by Spath as *Olcostephanus* (*O.*) aff. *astierianus* (d'Orbigny) and assigned a Lower Hauterivian age. It is from this formation that a fairly representative Berriasian–Valanginian ammonite fauna was collected during the present survey.

From the uppermost bed of Unit 4 ("Main Sandstone Series") poorly preserved gastropods, bivalves, echinoids, brachiopods and ammonites have been monographed. Amongst the ammonites Spath described *Douvilleiceras mammillatum* (Schlotheim), *Cleoniceras daviesi* Spath and *Brancoceras indicum* Spath etc. A Middle Albian age was assigned to the formation.

No fossils were recorded from Units 5 to 7. The present work indicates that the Unit 6 ("Variegated Series" of Davies) is not present in the area and the Upper and Lower Lithographic Limestone units follow each other conformably and are distinguishable as members of a formation. The limestone contains abundant small Foraminifera (*Globotruncana* sp.) and rarely ammonites (in the basal part).

Trans Indus Salt Ranges. Waagen (1875) compared the Jurassic rocks of the Salt Range with that of Cutch, and Wynne (1880) further pointed out the similarity of the "Golden Oolite" (Callovian) of Khera Hill of Cutch with similar rocks on either side of the River Indus. The strata that Wynne referred to as "Golden Oolite", a name also quoted in later literature (Arkell 1956 : 393), occur in a sandy, ferruginous formation (Pascoe 1959 : 1158), the "Variegated Series" of Gee (1945). Their stratigraphic position is much below the presently established Callovian beds in the uppermost part of the overlying "Baroch Limestone".

The most substantial contribution to the geology of the Salt Range and its Trans Indus extension could be attributed to E. R. Gee (1945) who divided the Jurassic and Cretaceous rocks as follows:

4.	"Lumshiwal Sandstone"	Cretaceous
3.	"Belemnite Beds"	Lower Cretaceous-Jurassic
2.	"Baroch Limestone"	Jurassic
1.	"Variegated Stage"	Jurassic

No precise ammonite horizons were reported from either the "Variegated Stage" or the "Baroch Limestone", but Spath (1933 : 802) recorded *Subkossmatia flemingi* (Fleming's collections) from the "Calcareous strata below the coal shales with belemnites" near Kalabagh. Spath also identified some fragmentary ammonites as *Hubertoceras* sp., *Obtusicostites* sp. and *Kinkeliniceras* sp. marked by the collectors "from the Belemnite Beds of Miranwal nala, Makerwal". He (1939 : 121) correctly thought their position to be below the "Belemnite Beds" in the Jurassic limestone. Spath (1933 : 802) mentioned some unlabelled ammonites housed in the British

Museum, which he considered to have come from the Chichali Hills in the Trans Indus Salt Ranges. He identified them as *Indocephalites transitotious* Spath, *Pleurocephalites habyensis* Spath and *Kamptokephalites magnumbilicatus* (Waagen). Because of their golden matrix. Spath first thought them to have come from Cutch. Krishnan (1960 : 419) placed the above mentioned ammonites in the limestone above the "Variegated Series" without reference to their locality. If the occurrence of the Lower Callovian ammonites from the Chichali Hills is correctly reported, they must be very rare as no such ammonites were detected in the Chichali Hills during the present survey.

A confusing account of some Upper Jurassic ammonites and belemnites (considered derived) is represented in the literature (Arkell 1956 : 393; Pascoe 1959 : 1159–1160; Spath 1933 : 802; 1939 : 162). These ammonites are believed to have come from the "Belemnite Beds" of Neocomian age. Pascoe (1959) reviewing the Jurassic rocks of the Salt Range and the Trans Indus Ranges, pointed out correctly the presence in these areas of Bathonian, Callovian and Tithonian (mentioned only from Sokun in the Main Salt Range). He, however, contended that several ammonite found in the overlying Cretaceous beds ("Belemnite Beds") appeared to have been derived from the Spiti Shales. Arkell (1956 : 393) similarly pointed out the overstepping of the Neocomian "Belemnite Beds" on the underlying Jurassic. The views expressed by Arkell, Pascoe and Krishnan are presumably based on Spath's analysis of the faunas who contended (1939 : 132) "there is no evidence that the Infra-Valanginian (Berriasian) and Lower Valanginian were ever represented in the Salt Range proper where the Middle and Upper Valanginian may rest upon the Tithonian. Conversely the Lower Valanginian must have been comparatively well developed in the west (Trans Indus Ranges) where, however, the Tithonian is completely absent in addition to the rest of the Upper Jurassic down to Callovian".

An Upper Oxfordian–Kimmeridgian–Tithonian–Berriasian–Valanginian ammonite sequence has been established in the "Belemnite Beds" by the present field investigations. These beds rest disconformably on the Middle Callovian ammonite bed of the "Baroch Limestone". The Jurassic–Cretaceous boundary is transitional and not disconformable as previously thought.

Shaikh Budin Hills. Lower Jurassic ammonites (*Bouleiceras* sp.) and Callovian brachiopods have been reported from this area (Pascoe 1959 : 1160–61). From a green glauconitic sandstone (possibly "Belemnite Beds") Sahani (1939) identified Oxfordian and Kimmeridgian brachiopods (*Zelleria* sp., *Kingena* sp.). Spath (1939 : 136) recorded *Hibolithes subfusiformis* (Raspail), *Cymatoceras* sp. and crioceratid fragments and concluded the presence of "Belemnite Beds" in the area. C. W. Wright (unpublished oil company report) identified *Blanfordiceras acuticostatum* (Uhlig) and *Virgatosphinctes communis* Spath from the basal part of the "black zone" ("Belemnite Beds"). Similar Tithonian ammonites were collected and are described here.

III. GENERAL SEQUENCE

The Mesozoic rocks of the area comprise of the following formations. The oldest is underlain disconformably (Para-conformity of Teichert and Kummel, 1966) by

Permian Chhiddru Formation and the youngest overlain disconformably by Palaeocene Hangu Formation or Dhak Pass Formation.

8.	Kawaghar Formation	Upper Cretaceous
	Disconformity	
7.	Lumshiwal Formation	Upper Jurassic to mainly Lower Cretaceous
6.	Chichali Formation	Upper Jurassic to Lower Cretaceous
5.	Samana Suk Limestone	Middle Jurassic
	Disconformity	
4.	Datta Formation	Lower Jurassic
	Disconformity	
3.	Kingriali Formation	? Upper Triassic
2.	Tredian Formation/ Chak Jabbi Limestone	? Middle Triassic
1.	Mianwali Formation	Lower Triassic

Mianwali Formation: The name Mianwali was used by Gee (in Pascoe, 1959 : 852) and formalized by Kummel (1966 · 373–374) as a formation for rocks referred to previously (Waagen 1875; Wynne 1878) as "Ceratite Limestone", "Ceratite Marls", "Ceratite Sandstone" and "Bivalve Beds". The formation is marine consisting of limestone, marls, with subordinate sandstone and dolomite. Kummel (1966) divided the formation into three members (Kathwai, Mittiwali and Narmia). The formation is 350–600 feet thick in the Salt Range and Trans Indus Ranges and 130 feet thick (base not exposed) in the Kala Chitta Range.

Tredian Formation/Chak Jabbi Limestone: The name Tedian was introduced by Gee (written communication to the Stratigraphic Committee of Pakistan) for rocks referred to earlier by him (1945) as Kingriali Sandstone in Salt Range and Trans Indus Ranges. It consists of shale (lower part) and sandstone (upper part). The thickness is 130–207 feet. In Kala Chitta the equivalent rocks which immediately overlie the Mianwali Formation are sublithographic, medium bedded, unfossiliferous limestone named here as Chak Jabbi Limestone. The thickness is 110 feet. No Tredian Formation lithology is developed in Kala Chitta.

Kingriali Formation: Overlying the Tredian Formation of the Salt Range and Trans Indus Ranges and the Chak Jabbi Limestone of Kala Chitta are the massive to thick bedded dolomite and dolomitic limestone of the Kingriali Formation, (the "Kingriali dolomite" of Gee, 1945). The unit is 300–350 feet thick and is probably present in Hazara and parts of Kohat.

Jurassic and Lower Cretaceous Formations: These comprise of clastic and carbonate rocks of marine to non-marine origin and are overlain and underlain disconformably by Upper Cretaceous and Triassic formations respectively. A disconformity between the Middle and Upper Jurassic is also present (Chapter IV).

Kawaghar Formation: The name Kawaghar is here adopted (after Day of Attock Oil Company) for rocks referred to previously as "Lithographic Limestone" in unpublished Geological Survey of Pakistan and Oil Companies reports. The formation is typically a lithographic to sublithographic grey limestone with subordinate marls and shale in Western Kohat and Hazara. In Eastern Kohat, Nizampur and northern

Kala Chitta, the lithology is mainly dark marls and calcareous shale with subordinate limestone. The thickness varies from 147 to 420 feet. The formation is missing in southern Kala Chitta, Salt Range and Trans Indus Ranges.

IV. STRATIGRAPHY OF THE JURASSIC AND LOWER CRETACEOUS ROCKS OF THE AREA

The ammonites described in this publication were collected from the following four formations which are over and underlain disconformably by Upper Cretaceous and Triassic rocks (fig. 4).

4.	Lumshiwal Formation 32–687 ft	Upper Jurassic to mainly Lower Cretaceous
3.	Chichali Formation 30–213 ft	Upper Jurassic to Neocomian
	Disconformity	
2.	Samana Suk Limestone 220–1087 ft	Middle Jurassic
1.	Datta Formation 60–1300+ ft	Lower to Middle Jurassic

These formations have large aerial extent. They show significant lateral facies changes and, in most areas, the lithological boundaries transgress time planes (fig. 5).

Datta Formation

The name Datta Formation was introduced by Danilchik (1961) from the Datta nala in the Trans Indus Salt Ranges for the "Variegated Stage" of Gee (1945). The name is here adopted for similar rocks (fig. 4) in western Kohat ("Lower Samana Beds" of Davies 1930), Kala Chitta Range ("Ferruginous Beds in the Kioto Limestone" of Cotter 1933, "Red Clay Zone" and "Sumbal Panni Clay" of Oil Company Geologists), and Hazara ("Maira Formation" of R. G. Davies and Gardezi 1965).

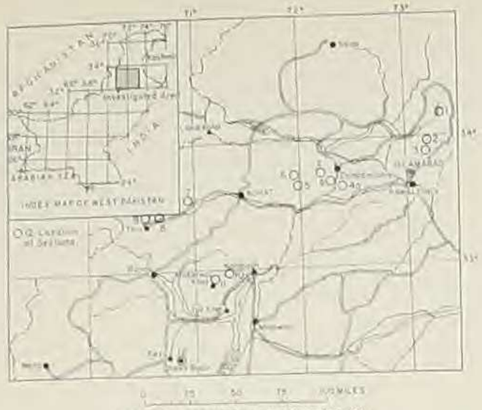
Trans Indus Ranges

This area forms the type locality of the Datta Formation. The lithology consists of variegated sandstone and shale with some argillaceous limestone interbeds in the upper part, and coaly, carbonaceous, ferruginous and fireclay beds in the lower part. It rests with a disconformity on the ?Upper Triassic Kingriali Formation and is transitional with the overlying Samana Suk Limestone.

The thickness ranges from 500 feet in Nammal Gorge to 700 feet in Datta nala (Danilchik and Shah (1967) and over 1300 feet in the Shaikh Budin Hills (Gee 1945; Habib Abbas and Bhuyan 1966, unpublished report). It thins out east of Nammal Gorge and is thick towards the west and south west in the Trans Indus Ranges.

Fauna and Age: Pascoe (1959 : 1160) has recorded *Bouleiceras* sp. from Shaikh Budin Hills (without any stratigraphic position or locality). Spath (1933 : 802) identified *Indocephalites* aff. *transitorious* Spath and *Kamtokephalites* cf. *magnumbilicatus* (Waagen) which he thought to have come from the Chichali hills in the Surghar Range.

Commenting on this fauna Spath (1933 : 802) said "on account of their matrix I have up to now taken them to be from Kachh (India). The preservation in



MAP SHOWING LOCATION OF GRAPHIC SECTIONS.

AGE		NOMENCLATURE USED		OBSOLETE NAMES
TERTIARY	PALAEOCENE	DHAK PASS FORMATION (For Sath Rang and Sautnala Portion)	HANGU FORMATION (Kohat)	DHAK PASS BEDS HANGU SANDSTONE
		Disconformity		
CRETACEOUS	UPPER	KAWAGARH FORMATION		LITHOGRAPHIC LIMESTONE KAWAGARH MARLS DARSAMAND LIMESTONE DURPANI LIMESTONE
		Disconformity		
	LOWER	LUMSHIWAL FORMATION		SUMAL SANDSTONE KHADIMAKH FORMATION MAIN SANDSTONE SERIES
		CHICHALI FORMATION		BELEMNITE BEDS SPITI SHALE
		Disconformity		
JURASSIC	UPPER	SAMANA SUK LIMESTONE		BAROCH LIMESTONE RIOTO LIMESTONE
	MIDDLE	DATTA FORMATION		RIOTO LIMESTONE VARIEGATED SERIES
	LOWER			LOWEST SAMANA BEDS
		Disconformity		
TRIASSIC	UPPER	KINGRIALI FORMATION		KINGRIALI DOLOMITE RIOTO LIMESTONE
	MIDDLE	TREDIAN FORMATION (Soli Range & Trans-Indus)	KALACHITTA LIMESTONE (Kalachitta Range)	KINGRIALI SANDSTONE
	LOWER	MIANWALI FORMATION		OOLITIC DOLOMITE BIVALVE BEDS CERATITE BEDS

INDEX TO LITHOSTRATIGRAPHIC UNITS FOR HAZARA KALACHITTA, NIZAMPUR KOHAT, TRANS INDUS SALT RANGE AND SHEIKH BUDIN HILLS.

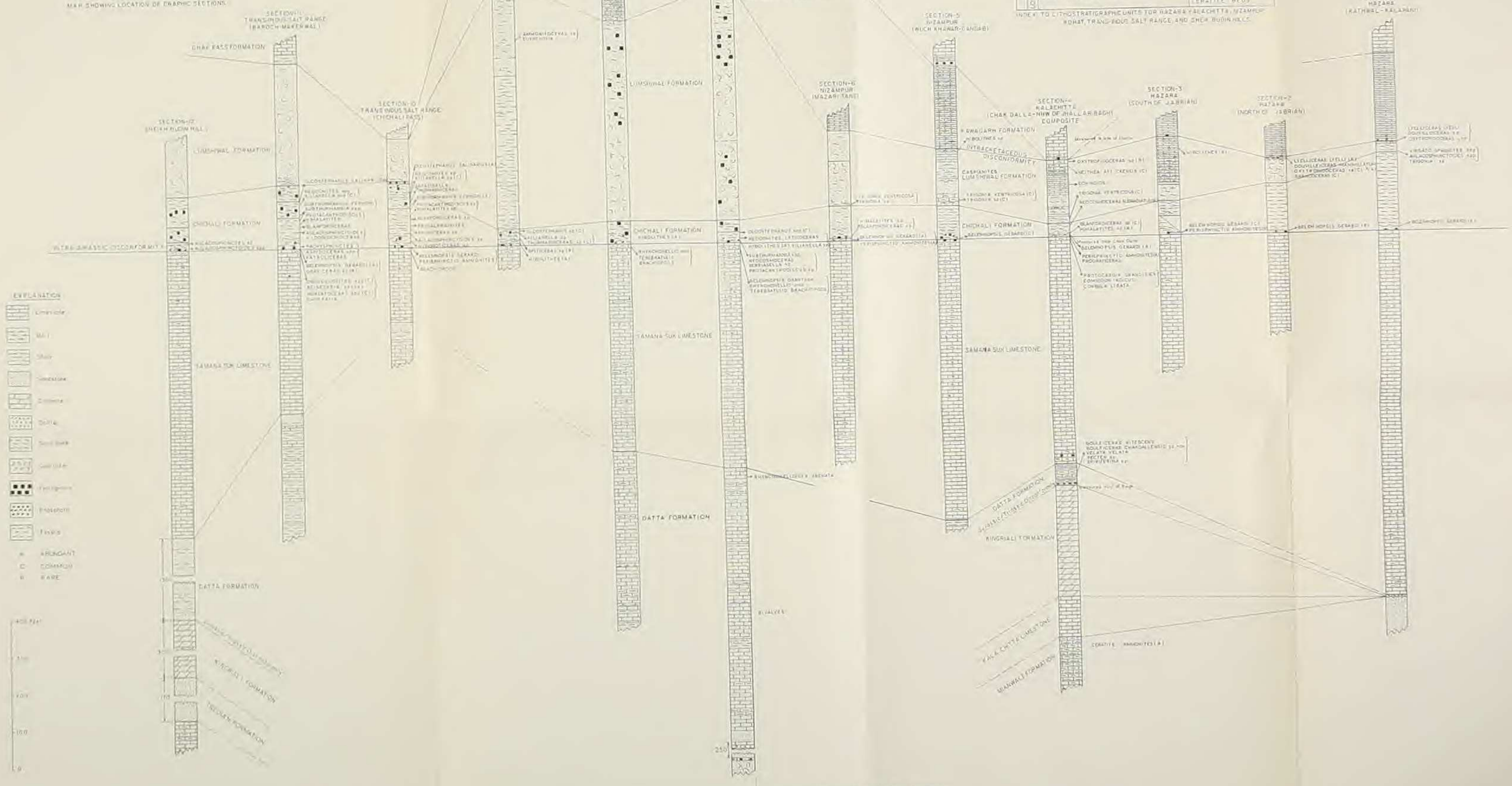


FIG. 3. Lithological sections of the Mesozoic rocks of Hazara, Kala Chitta, Nizampur, Kohat, Trans Indus Ranges including Shaikh Budin Hills, West Pakistan.

the characteristic yellow and crimson matrix of the ferruginous 'macrocephalus' beds is identical with that of certain undoubted Kachh examples". The same fauna has been listed by Krishnan (1960 : 410) and Pascoe (1959 : 1160) from the limestone which overlie the "Variegated stage" in the Trans Indus Ranges. Spath (1933) further pointed out the similarity of "golden oolite" of Cutch with the "golden oolite" referred by Wynne (1878 : 101; 1880 : 46–47) from the Salt Range and the Trans Indus Extension. Wynne's so-called "golden oolite" occurs in the upper part of the Datta Formation (Pascoe 1959 : 1158). If the *Bouleiceras* and other ammonites are correctly reported the Datta Formation in this area is Lower to Middle Jurassic in age and may be correlated with Western Kohat.

In the present Survey, no Lower Callovian ammonites were found in the Chichali hills (mentioned by Spath 1933), and this occurrence may still be regarded doubtful until their correct stratigraphic position or occurrence is established by future work.

Kala Chitta–Nizampur area: In the Kala Chitta Range a rather confused name of "Kioto Limestone" was used by Cotter (1933) for the limestone below the "Giumal and Spiti" sequence. An Upper Triassic to Liassic age was assigned by Cotter. The upper age limit was later extended to Upper Bathonian on the basis of the similarity of bivalves with the Kaur Bet Beds of Cutch (Arkell) 1956 : 400. During the present study it was found that the "Kioto Limestone" of Cotter consists of five distinct formations, and the Triassic–Jurassic contact is disconformable. The five divisions are as follows (fig. 4: Section 4).

5.	Samana Suk Limestone	620 ft Middle Jurassic
4.	Datta Formation	61 ft Lower Jurassic
	Disconformity	
3.	Kingriali Formation, dolomite, dolomitic limestone, massive, thick bedded, brown to greyish brown	300 ft ? Upper Triassic
2.	Chak Jabbi Limestone, grey, medium bedded, lithographic to sublithographic limestone, unfossiliferous, slightly dolomitized in beds and equivalent to Tredian Formation ("Kingriali Sandstone") of the Salt Range.	110 ft ? Middle Triassic
1.	Mianwali Formation, thin bedded limestone, calcareous shale and marls, green, grey, argillaceous with abundant ammonites	130+ ft Lower Triassic (base not exposed)

The Triassic sequence: The Lower Triassic Mianwali Formation is exposed in the faulted outcrops north of Chak Jabbi Rest House (43 C/6) and in the core of the anticline one mile east south east of Bagh (43 C/1).

The ammonites (to be studied and described) include *Owenites*, *Anokashmirites*, *Subvishnuites*, *Xenoceltites*, *Xenodiscoides*, *Koninckites*, *Kymatites* and *Paranorites*.

The ammonites are typically Scythian and represent a mixed Himalayan and Salt Range assemblage.

The Mianwali Formation is overlian by Chak Jabbi Limestone in Kala Chitta which stratigraphically hold the same position as the Tredian Formation in Salt Range and Trans Indus Ranges. The formation is well exposed in Bagh and Chak Jabbi outcrops. It is overlain by the thick cliff-forming, brown weathering Kingriali Formation.

Overlying the Triassic Kingriali Formation with a marked disconformity (best seen in the Chakdalla section) is the Datta Formation of Kala Chitta Range. In a measured section near Chakdalla (43 C/6), the Datta Formation is 61 feet thick and can be divided into three members. The upper member (19 ft) is red clays and thin bedded limestone. The middle member (22 ft) is grey, nodular marly limestone with *Bouleiceras* and other fossils. The lower member consists of red and white quartzose and hematitic sandstone with (locally) fire clay horizons. As compared to the Salt Range, Trans Indus Ranges and Western Kohat, the thickness is much reduced in the Kala Chitta Range.

Fauna and Age: The fauna from the middle member consists of *Bouleiceras nitescens* Thevenin, *Bouleiceras chakdallaense* sp. nov., *Spiriferina* sp. *Vela ta velata* (Goldfuss), *Pecten* sp. (similar to *Indopectan* sp. figured by Cox 1935 from this area), *Lima* (*Plagiostoma*) *gigantea* J. Sowerby and indeterminate corals and gastropods. The age of the middle member is Lower Toarcian and the age of the formation in the Kala Chitta area is Lower Jurassic (mainly Toarcian).

Western Kohat (*Samana Range*)

The Datta Formation in Western Kohat shows a significant facies change, and consists of thin to medium bedded, grey to brownish grey limestone with interbedded sandstone, calcareous sandstone, sandy, oolitic limestone and shale. In a measured section north east of Shinawari, on the western end of the Samana Range, the thickness is over 1300 feet, the base being faulted against Tertiary shale. The upper contact is gradational with the overlying Samana Suk Limestone (fig. 4, section 7).

The Datta Formation is not exposed in the Khadimakh section, but north of Darsamand 500 to 600 feet crops out in the core of an anticline. In the Tribal Hills north and east of the Samana Range and Shinawari a greater thickness seems to be developed, but due to inaccessibility of this area it has not yet been studied. As correctly pointed out by Davies (1930) the possibility of Triassic rocks in the Tribal Hills to the north and east of the Samana Range cannot be ruled out.

The Datta Formation of Western Kohat is of shallow-water marine origin as contrasted to the mixed marine (upper) and continental (lower) type in the Salt Range Trans Indus Ranges, Kala Chitta and Hazara. The lithology is more closely comparable with rocks of Lower and Middle Jurassic age of the Sulaiman province (Baluchistan and Kurram).

Fauna and Age: In the upper part, rhynchonellid brachiopods occur which were also recorded by Davies (1930) and identified by Muir Wood (1930 : 26) as *Rhyn-*

chonelloidea arenata (Quenstedt) of Upper Bathonian or Lower Callovian age. The presence of *Spiriferina* sp., *Velata* sp. and indeterminate ammonite fragments (oxyconic with complicated suture) in the lower beds indicates a Lower Jurassic age similar to the bivalves and brachiopods of the Toarcian beds of the Kala Chitta Range. The age of the Datta Formation in Western Kohat may, therefore, be considered like that of the Trans Indus Ranges as Lower to Middle Jurassic (Pre Callovian).

Hazara

The present investigation does not cover a detailed stratigraphic study of the Datta Formation in Hazara. In one measured section, north of Kalapani, of the "Kioto Limestone" (treated here under Samana Suk Limestone), the Datta Formation lithology is not developed, partly due to intensive folding and faulting, and partly due to non-deposition (fig. 6). In the Galdanian area, north west of Kalapani (43 F/7) Calkins and Matin (1968 : 15) recorded "Red Beds" with hematitic shale, sandstone and limestone ("Galdanian formation") underlying conformably their "Daulatmar limestone" (Samana Suk Limestone) and overlying a dolomitic limestone unit ("Abbottabad formation"). These "Red Beds" are considered Lower Jurassic in age and possibly represent the Datta Formation (similar to the Red Beds of Kala Chitta). The underlying dolomitic limestone is similar to the Kingriali Formation of ?Upper Triassic age. These correlations are tentative, based on the present study of the Kala Chitta Range and the similarity of the so-called "Kioto Limestone" of Hazara with that of Kala Chitta (Cotter 1933).

Davies and Gardezi (1965) found *Bouleiceras* sp. in a section near Bagnotar (43 F/8), Hazara, in the middle part of the "Maira formation", (=Datta Formation) which overlies "Hazara slates" disconformably and underlie their "Jurassic limestone" (=Samana Suk Limestone). The thickness varies from 100 to 120 feet (1965 : 25). The lithology shows a strong similarity with that of Kala Chitta Range.

Fauna and Age: The presence of *Bouleiceras* in the Bagnotar area of Hazara and the strong similarity of this section with Kala Chitta indicate a Lower Jurassic (mainly Toarcian) age of the formation which rest disconformably on Precambrian, Paleozoic or Triassic rocks (figs 4, 5), and is not developed in parts of Hazara (e.g. Kalapani section).

Samana Suk Limestone

The name Samana Suk was introduced by L. M. Davies (1930) from the peak of this name in the Samana Range, Western Kohat. The name is here adopted for similar limestones of the Kala Chitta Range (part of "Kioto Limestone" of Cotter 1933), the Salt and Trans Indus Ranges ("Baroch Limestone" of Gee 1945) and Hazara (part of "Kioto limestone" of Middlemiss 1896; "Jurassic limestone" of Davies and Gardezi 1965; "Daulatmar limestone" of Calkins and Matin 1968).

Western Kohat (Samana Range)

In the type area the Samana Suk consists of grey, medium grey to dark grey, thick to medium bedded limestone with oolitic, calcareous shale and marl interbeds.

The thickness varies from 615 feet in the Samana Range (western outcrops near Shinawari) to 562 feet in the Darsamand section.

The formation is gradational with the underlying Datta Formation, and is overlain disconformably by the Chichali Formation.

Fauna and Age: The fossils are mostly comminuted shells (bivalves, gastropods and brachiopods). About 3 feet below the top belemnites (*Belemnopsis* cf. *grantana*) were obtained from a shale parting on the south flank of the Samana anticline. The top uneven surface of the limestone, which weathers rusty brown, has sectioned belemnites, molluscan casts and crinoidal remains. On the basis of *Belemnopsis granata* (d'Orbigny), which is similar to the figured specimen of Spath (1924, pl. III, fig. 3) from Cutch, the upper age limit of the formation is dated as Middle Callovian, and the formation may range in age from Middle to Lower Callovian.

Trans Indus Ranges

The Samana Suk Limestone is similar in lithology to the type locality, except the bedding is thinner and the colour is lighter grey. The formation is 220 feet in the Chichali section. It thins out towards the east in the Salt Range, but thickens to 450 feet in Baroch nala towards the west. Further south, in the Shaikh Budin Hills, Krishnan (1960 : 419) recorded 800 feet of the limestone.

The uppermost 2 to 3 feet of the formation is richly fossiliferous in ammonites, particularly in the area west of Chichali Pass (Datta, Punnu, Lunda, Mallakhel, Makerwal), and has yielded the Middle Callovian ammonites described in the present work. In the sections east of the Chichali Pass no ammonites were detected in this horizon, but Spath (1928 : 205) has recorded *Subkossmatia flemingi* from north of Kalabagh.

Fauna and Age: The ammonites include *Reineckeia anceps* (Reincecke), *R.* sp. indet. *R.* cf. *torulosus* (Spath), *Choffatia* sp. indet., *Hubertoceras* sp. indet., *Obtusicostites buckmani* Spath and *Obstuicostites* sp. indet.

Among the non-ammonite fauna, rhynchonellid and terebratulid brachiopods, bivalves and gastropods occur quite commonly. The Bivalves include *Homomya* cf. *gibbosa* Sowerby, *Pecten* sp., *Arctostrea* sp. and *Tellurimya tellaris* (Lamarck). Among the rhynchonellids *Somalirhynchia nobelis* (J. De C. Sowerby) is the most abundant species in some sections.

The upper age limit of the formation is Middle Callovian and the formation may extend in age from Middle to Lower Callovian (Middle Jurassic).

Kala Chitta Nizampur area

The Samana Suk Limestone in this area (upper part of the "Kioto Limestone" of Cotter 1933) consists of thin to medium bedded limestone with thicker interbeds.


TRIASSIC
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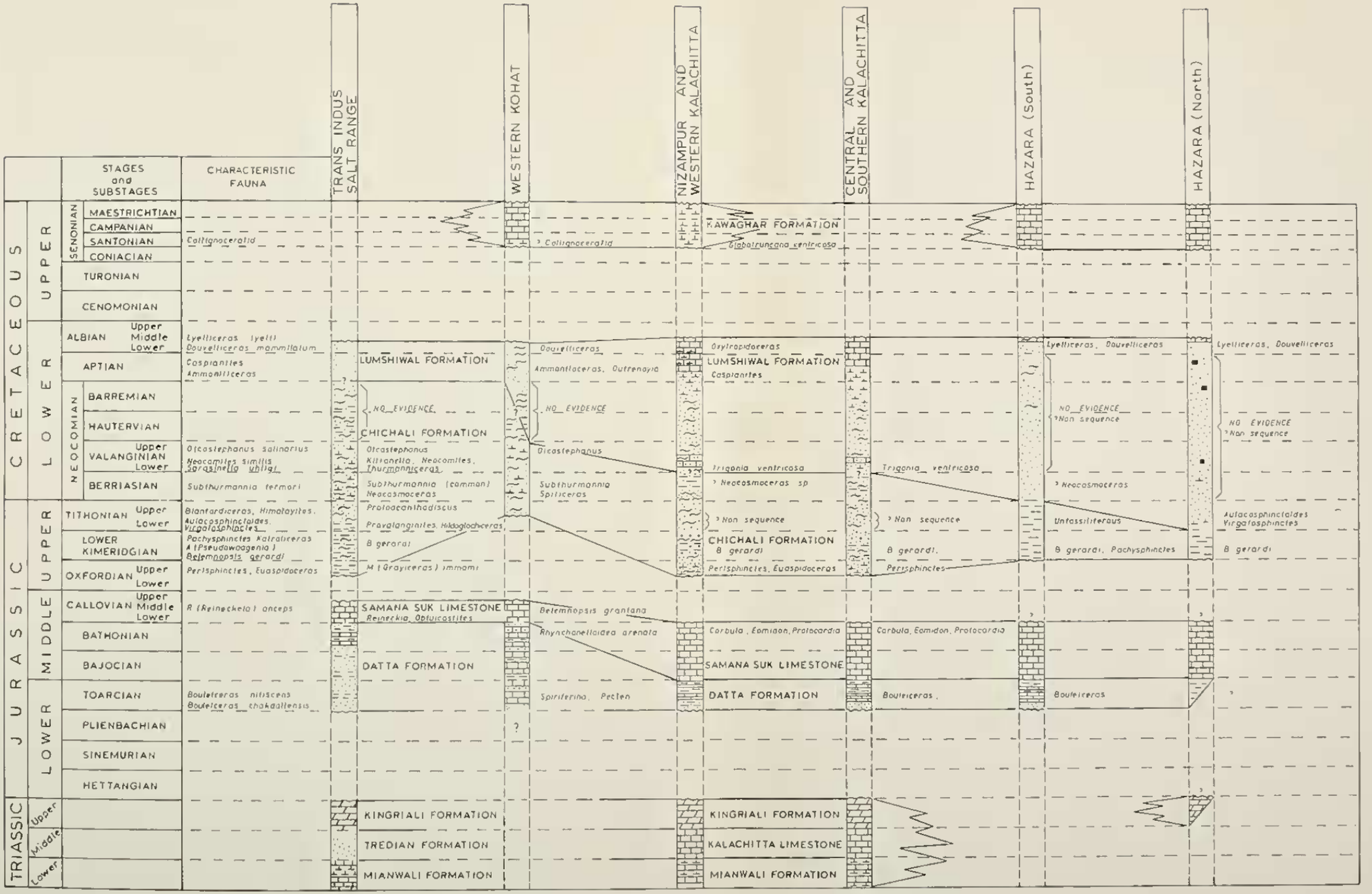

Fig. 4. Biostratigraphical correlation of the Mesozoic formations of northern West Pakistan.

The limestone weathers to grey-brown and has subordinate nodular marl and calcareous shale intercalations. The succession is gradational to the underlying Datta Formation and is disconformably overlain by the Chichali Formation.

Nearly 10 feet above the basal shelly limestone occurs a distinct yellow brown to dark rusty brown ferruginous coarse oolitic bed of 2 to 5 feet in thickness. This ferruginous oolite bed is developed in the western half of Kala Chitta (West of Chak Jabbi), while in the eastern section, it is represented by calcareous oolites only.

The upper 1 or 2 feet of the Samana Suk Limestone are nodular, marly and have yielded bivalves.

The thickness in a measured section near Chakdalla is 620 feet. In the Gandab section of Nizampur, the thickness increases to 800 feet.

Fauna and Age: The bivalves in the top bed of the formation include *Protocardia grandidieri* (Newton), *Eomiodon indicus* Cox and *Corbula lyrata* J. de C. Sowerby. The bivalves are the same as described by Cox (1935) from the "Kioto Limestone" of this area. They are also similar to the one occurring in the Kuar Bet Beds of Cutch, which have been assigned an Upper Bathonian age (Arkell 1956 : 391, 400).

The upper age limit of the Samana Suk Limestone in Kala Chitta is Upper Bathonian, and as the formation overlies the known Toarcian Datta Formation of this area conformably, the lower age limit may extend to Bajocian.

It is worth mentioning that nearly 60 to 70 miles further west in the Samana Range, and 50 to 60 miles south west in the Trans Indus Ranges, the Samana Suk Limestone is Callovian.

Hazara

In the Hazara area the formation was studied only in one section, situated 1½ miles north of Kalapani (43 F/8). The lithology comprises thick to medium bedded (with thin beds) grey, brownish grey limestone, poorly fossiliferous, with interbeds of oolitic dolomitized limestone, nodular marl and calcareous shale. It is disconformably overlain by dark shale of the Chichali Formation ("Spiti Shales"), and disconformably underlain by quartzites and slates of doubtful Palaeozoic age. The basal 3 feet of the limestone is conglomeratic with quartz pebbles.

The thickness is 1087 feet in the section north of Kalapani.

From the Bagnotar area to the south R. G. Davies and Gardezi (1965 : 25) reported over 1200 feet of similar limestone overlying their "Maira Formation" (=Datta Formation with *Bouleiceras*). Calkins and Matin (1968) from the Galdanian area recorded thick, grey limestone ("Daulatmar Limestone") overlying their "Galdanian formation" (=Datta Formation). This limestone probably represents the Samana Suk Limestone.

Fauna and Age: The Samana Suk Limestone of Hazara is poor in identifiable fossils. No ammonites occur. Its stratigraphic position above the Lower Jurassic *Bouleiceras*-bearing Datta Formation, lithological similarity with that of the Kala Chitta area and its disconformable contact with the overlying Upper Jurassic Chichali Formation, suggest a Middle Jurassic age similar to the Kala Chitta Range.

Chichali Formation

The name Chichali Formation was introduced by Danilchik (1961) and Danilchik and Shah (1967) from the Chichali pass in the Trans Indus Ranges for rocks previously described as "Belemnite Beds" (Spath 1939; Gee 1945). The name is here adopted (fig. 4) for similar rocks which disconformably overlie the Samana Suk Limestone in Kala Chitta ("Spiti Shales" of Middlemiss 1896) and Shaikh Budin Hills ("Black Zone" of oil company geologists).

Trans Indus Ranges

The lithology in the Trans Indus Ranges, which includes the type locality, consists of dark green, greenish brown, dark bluish grey (lower part), soft glauconitic sandstone and sandy shale, with subordinate nodular, calcareous, phosphatic strata. Some portions of the formation (the Middle member in Makerwal area and the Upper member in Chichali–Kalabagh area) are sufficiently rich in glauconite and/or chamosite to provide low grade iron ore.

The thickness ranges from 150 feet in the eastern section of Kalabagh to 180 feet in the Chichali Pass and 185 feet in the western sections of Makerwal and Baroch Nala. From the Shaikh Budin Hills, Abbas and Bhuyan reported (unpublished) a maximum thickness of 159 feet.

The formation is divisible into three members. The basal bed of the lower member (less than a foot in thickness) is calcareous, glauconitic and sandy, with Upper Oxfordian ammonites and belemnites. These are succeeded by dark grey silty, sandy, glauconitic shale (10–15 ft), which contains some calcareous, phosphatic, or ferruginous nodules with Lower Kimmeridgian ammonites and abundant belemnites (including *Belemnopsis gerardi*). The shale becomes gradually more sandy and greenish in colour in the succeeding 20 to 30 feet and has yielded Lower Tithonian ammonites and abundant *Hibolithes* but no *Belemnopsis*. The rest of the lower member passes into a dark green, glauconitic sandstone weathering into soft sands with Upper Tithonian ammonites. In the uppermost 2 to 3 feet the first basal Cretaceous ammonites (*Subthurmannia*) appear, and it is this part which is considered transitional from the Jurassic to the Cretaceous. The thickness of the lower member ranges from 70 to 75 feet in the Makerwal–Lunda–Punnu Mines sections, to 110 feet to the east in Chichali Pass and Kalabagh sections.

The middle member is a massive, calcareous, glauconitic sandstone, weathering rusty brown to greenish brown (dark green when fresh). It has abundant belemnites and common ammonites. The lower 3 to 4 feet of the member has Berriasian ammonites and the rest Valanginian. In the uppermost 2 to 3 feet Upper Valanginian ammonites (*Olcostephanus*) are commonly distributed. The thickness ranges from 35 to 45 feet in the Makerwal–Punnu Lunda Mines sections to 25 to 30 feet in the Kalabagh and Chichali Pass sections. The middle member thins towards the east, and in the Shaikh Budin Hills a maximum of 40 feet has been reported.

The upper member consists of greenish or reddish brown, massive, sandy shale

and sandstone which are glauconitic and chamositic but are devoid of ammonites. In the Chichali Pass and western sections about 3 to 5 feet below the top contact with the Lumshiwal Formation some *Hibolithes* and *Gryphaea* occur. In the rest of the member even belemnites, which are abundantly distributed in the lower and middle members, are absent. The upper contact with the Lumshiwal Formation in the sections west of the Chichali Pass appears to be transitional. In the sections at and east of the Chichali Pass, the upper contact with the Lumshiwal Formation is marked by a red ferruginous sandstone bed and is sharp. The thickness of the upper member is 10 feet in Kalabagh, 40 feet in the Chichali Pass, 60 feet in the Makerwal–Lunda–Punnu Mines and 80 feet in the Shaikh Budin Hills. The upper member shows a marked thinning towards the east (Main Salt Range).

Fauna and Age: The Upper Oxfordian fauna includes *P.* (*Kranaosphinctes*) sp. indet., *P.* (*Dichotomosphinctes*) cf. *rotoides* Ronchadze, *P.* (*?Dichotomosphinctes*) sp. indet., *Mayaites* cf. *waageni* (Uhlig), and *Belemnopsis gerardi* (Oppel).

The Lower Kimmeridgian is represented by *Aspidoceras* (*Aspidoceras*) sp. indet., *A.* (*Pseudowaagenia*) sp. indet., *Physodoceras* (*Simaspidoceras*) sp. indet., *Laevaptychus*, *Ptychophylloceras ptychoicum* (Quenstedt), *Katroliceras* cf. *pottingeri* (J. de C. Sowerby), *Pachysphinctes robustus* Spath, *Hibolithes* sp., *Belemnopsis gerardi* and *Hybonoticeras* sp. indet. The non-cephalopod fauna consists of *Gryphaea* sp., some rhynchonellid and terebratulid brachiopods.

The Lower Tithonian is represented by *Aulacosphinctoides* sp., *Virgatosphinctes* sp., *Hildoglochioceras* sp. indet., *Proniceras indicum* Spath, *Provalanginites rhodesi* gen. nov. sp. nov., *Provalanginites howarthi* sp. nov., *Holcophylloceras silesiacum* (Oppel). The Upper Tithonian fauna includes *Blanfordiceras* cf. *wallichi* (Grey), *Himalayites* cf. *hyphaisis* (Blanford), *Himalayites* sp. indet., *Pterolytoceras exoticum* (Oppel), *Spiticeras multiforme* Djanelidze, *Ptroacanthodiscus* cf. *michaelis* (Uhlig), *Protacanthodiscus* sp. indet., and *Aulacosphinctes spitiensis* (Uhlig).

This Upper Oxfordian to Tithonian fauna occurs in the lower member of the Chichali Formation. In the upper 2 feet, however, *Subthurmannia* appears, and extends into the basal 3 to 4 feet of the middle member. The Jurassic–Cretaceous boundary is placed at the first appearance of the genus *Subthurmannia*.

The Berriasian is represented by *Protacanthodiscus* sp., *Subthurmannia fermori* Spath (abundant), *S. lissonioides* Spath and other *Subthurmannia* spp., *Neocosmoceras subradiatus* (Uhlig), *Neocosmoceras* cf. *spitiensis* (Uhlig), and *Spiticeras* (*Negreliceras*) aff. *subnegreli Djanelidze*.

The Lower Valanginian (Middle member of the Chichali Formation) is represented by *Thurmanniceras* sp., *Sarasinella uhligi* Spath, *Sarasinella spinosa* (Uhlig), *Neocomites* (*Neocomites*) sp. nov., *N.* (*Neocomites*) cf. *teschensis* (Uhlig), *N.* (*Neocomites*) *pycnoptychus* (Uhlig), *N.* (*Calliptychoceras*) spp. nov., *N.* (*Parandiceras*) cf. *rota* (Spath), *N.* (*Parandiceras*) *theodorii*, (Oppel), *N.* (*Parandiceras*) aff. *indicus* (Uhlig), *N.* (*Odontodiscoceras*) *similis* Spath, and its subspecies, *Uhligites* sp. indet. *Kilianella asistica* Spath, *K. besairei* Spath, *Kilianella* sp. nov., *Neohoploceras* (*Neohoploceras*) sp. indet. and *Neohoploceras baumbergeri* Spath.

The Upper Valanginian is represented in the uppermost 2 to 3 feet of the middle member by *Olcostephanus* (*Olcostephanus*) *salinarius* and its 5 subspecies (most

common), *O.* (*O.*) *sakavalensis* (Besairie), *O.* (*O.*) cf. *filosa* (Baumberger), *O.* (*O.*) *sublaevis* Spath, *O.* (*O.*) *fascigerus* Spath, *O.* (*O.*) sp. nov., *O.* (*O.*) aff. *geei* Spath, *O.* (*Rogersites*) *schenki* (Oppel), *O.* (*R.*) sp. nov., *Leopoldia* sp., *Distoloceras* sp. and *Lyticoceras* sp. nov.

No ammonites occur in the upper member excepting for some poorly preserved *Gryphaea* and *Hibolithes* in the upper part.

The ammonite fauna indicates an Upper Oxfordian to Valanginian age of the lower and middle members. The upper Member may represent the rest of the Neocomian (Hauterivian–Barremian).

Western Kohat (Samana–Darsamand–Khadimakh sections)

The lithology is very similar to the type section of the Trans Indus Ranges except that the thickness is much attenuated (50–60 ft). In the Samana–Darsamand area, the formation is divisible into three members, but in the Khadimakh section only two fold division (corresponding to lower and middle members of the Samana section) is possible. The upper member in Khadimakh is not separable from the overlying Lumshiwal Formation of similar lithology (fig. 4).

The formation rests disconformably on the Samana Suk Limestone, and is followed by the glauconitic (in Khadimakh) or quartzose sandstone of the Lumshiwal Formation.

Fauna and Age (fig. 5): The ammonites in the lower member include ?*Protacanthodiscus* sp., *Berriasella* sp., *Spiticeras* (*Spiticeras*) aff. *greisbachi* (Uhlig), *S.* (*S.*) cf. *mojsvari* (Uhlig), *Neocosmoceras octagonum* (Blanford) and *Subthurmannia* aff. *boissieri* (Pictet). These are followed in the basal part of the middle member by *Subthurmannia fermori* Spath, *S.* aff. *pseudopunctata* Spath, *S. lissonioides* Spath, *Pterolytoceras* aff. *exoticum* (Oppel), *Pterolytoceras* sp. indet., *Thurmanniceras* sp. and *Neolissoceras grasianum* (d'Orbigny). Succeeding these faunas in the middle member are *Neocomites* sp., *Kilianella* sp. nov. and *Kilianella leptosma* (Uhlig). This is followed, in the upper 2 to 3 feet of the middle member by *O.* (*O.*) *salinarius* Spath, *O.* (*O.*) *radiatus* Spath, *O.* (*O.*) cf. *sublaevis* Spath, *O.* (*O.*) sp. nov., *O.* (*O.*) *pachycyclus* Spath and *Lyticoceras* sp. indet.

The upper member is barren of fossils. The age of the Chichali Formation is Upper Tithonian to Neocomian.

Kala Chitta–Nizampur area

The Chichali Formation of this area is broadly comparable in lithology with the Trans Indus Ranges and the Samana Range, but it also shows some peculiarities which require separate treatment.

In the outcrops of Western Kala Chitta (Bagh, Sujhanda sections) and south east of Nizampur (Wuch Khawr and Gandab sections) the formation is 80 to 90 feet thick

and consists of two members. The Upper Member is a dark pyritic silty shale, and is not developed in the outcrops of central Kala Chitta (Chakdalla–Jhallar sections) where the formation is 30 to 40 feet thick and consists of dark green or grey glauconitic sandstone and sandy shale with a nodular calcareous bed at the base.

In the sections north–north west of Jhallar, central Kala Chitta Range, the formation consists of the following:

Upper part — Greenish sandy shale, glauconitic with *Hibolithes* sp., *Gryphaea* sp. annelids, overlain by light brown calcareous sandstone of the Lumshiwal Formation 20 to 15 feet.

Lower part — Dark green, glauconitic, soft sandstone, with phosphatic and calcareous nodules, containing the following fossil horizons: 20 to 15 feet

d. near the top, *Neocosmoceras subradiatus* (Uhlig) and *Gryphaea* aff. *balli* (Stefanini).

c. major portion of the unit; abundant *Hibolithes* sp., *Gryphaea* cf. *balli* (Stefanini), and less commonly *Himalayites* sp., and *Blanfordiceras* sp. towards the base.

b. belemnite shingle (up to 1 ft) consisting of nodular (calcareous, ferruginous) glauconitic silty sands, with abundant *Belemnopsis gerardi* (Oppel) and *Hibolithes* sp., and some gastropods and bivalves.

a. sandy glauconitic, calcareous, rubbly bed (up to $1\frac{1}{2}$ ft), with abundant poorly preserved perisphinctid ammonites, brachiopods, bivalves, gastropods, belemnites; overlies disconformably the Samana Suk Limestone.

Fauna and Age (fig. 5): The lithology and fossil beds indicate that, though the formation ranges in age from Upper Oxfordian to Lower Neocomian, it is much condensed and is full of non-sequences.

The Upper Oxfordian fauna (unit a) includes *Prosophinctes* (?) *virguloides* Waagen, *P.* (*P.*) sp. indet., *P.* (*Arisphinctes*) *orientalis* Siemiradzki, *P.* (?*Dichotomosphinctes*) sp. indet. *Euaspidoceras* cf. *wagurense* (Spath), *Euaspidoceras* sp. indet., and the bivalves and gastropods include *Ctenostreon proboscideum* (J. Sowerby) and *Pleurotomaria* sp.

There is no evidence from the ammonites of the presence of Lower Tithonian, but the abundance of *Belemnopsis gerardi*, rare fragmentary perisphinctid ammonites and *Gryphaea* cf. *balli* (Stefanini) in the condensed horizon (unit b), indicate the presence of Lower Kimmeridgian. The Lower Tithonian is probably missing because of non-sequences in Kala Chitta. The Upper Tithonian is represented by *Himalayites* cf. *depressus* Uhlig, *Blanfordiceras* sp. indet and *Aulacosphinites* sp. indet. and *Gryphaea* cf. *balli* (Stefanini). *Gryphaea* is also commonly distributed in the glauconitic sands (unit c) in beds which overlie *Blanfordiceras*. It may be pointed out that the *Blanfordiceras* specimens are limonitic and occur towards the base of unit c.

The Berriasian is indicated by the presence of fragmentary specimens of *Neocosmoceras* cf. *subradiatus* (Uhlig).

Because of the presence of *Trigonia ventricosa* (Krauss) in the basal beds of the

overlying Lumshiwal Formation, which in Cutch and South Africa (Arkell 1956 : 387) is found in the Valanginian, the upper age limit of the Chichali Formation in Kala Chitta may be Lower Valanginian.

Hazara

In Hazara the Chichali Formation shows a distinct facies change from the dark "Spiti shales" type exposed in the outcrops north of Haro River (investigated west of Jabrian and in Kathwal–Kalapani sections) to the Kala Chitta type dark green glauconitic sandstone facies exposed south of Haro River (investigated north of Jabrian Rest House and extending to the south west in the Margala Hills).

The "Spiti Shales" facies is represented by black or dark grey shale with some ferruginous, sandy and silty concretions. The shales are unfossiliferous, except in the lowermost part where some belemnites (*Belemnopsis* sp.) and fragmentary perisphinctid ammonites occur. The formation rests disconformably on the Samana Suk Limestone ("Kioto limestone"), and is followed without any apparent break, but with change of lithology, by the Lumshiwal Formation ("Giumal sandstone").

The thickness in the section north northwest of Kalapani is 213 feet and thins out to 134 feet to the south in a roadside section near Jhamiri village.

The green glauconitic sandy facies of the Chichali Formation is 110 feet thick in a measured section north of Jabrian Rest House on the Haro River (north bank).

Fauna and Age: The formation is poor in ammonites and other fossils. The occurrence of *Belemnopsis gerardi* (Oppel) and poorly preserved, phosphatized fragmentary perisphinctid (?*Pachysphinctes* sp.) ammonites in the basal part indicate a Lower Kimmeridgian age for the base. It appears that the condensed Upper Oxfordian bed developed in Kala Chitta and the Trans Indus Ranges is missing from this area. *Belemnopsis gerardi* (Oppel) occurs both in the Upper Oxfordian and Lower Kimmeridgian beds of the Trans Indus and Kala Chitta Ranges. Unless more definite evidence of Upper Oxfordian age (based on ammonites) is obtained by future investigations of other outcrops, a Lower Kimmeridgian age is favoured here for the base of the formation.

The upper age limit of the Chichali Formation in Hazara is still less definite, mainly because of the paucity of fossils. In the Kalapani–Kathwal sections Lower Tithonian ammonites occur in the basal part of the overlying Lumshiwal Formation ("Giumal Sandstone") indicating mainly a Lower Kimmeridgian age of the Chichali Formation in these sections.

In the sections of Haro River, no fossil evidence could be obtained from the upper part of the formation, but Spath (1933) and Pascoe (1959) have reported *Neocosmoceras subradiatus* (Uhlig) and *Neocosmoceras octagonides* (Uhlig) from the overlying "Giumal sandstone" in outcrops 10 to 15 miles north east of the examined localities (Murree–Abbottabad Road). This suggests that the upper age limit of the Chichali Formation in the Haro River sections (Jabrian) may be Tithonian and the formation may extend from Lower Kimmeridgian to Tithonian.

Lumshiwal Formation

The name Lumshiwal was introduced by E. R. Gee (1945) for a white or light coloured sandstone overlying the Chichali Formation ("Belemnite Beds") and overlain disconformably by the Lower Tertiary coal beds in the Trans Indus Ranges. The name Lumshiwal Formation is here adopted for similar rocks previously called the "Main Sandstone Series" (Davies 1930) in the Samana Range, and "Giumal sandstone" in Kala Chitta (Cotter 1933) and Hazara (Middlemiss 1896).

The formation exhibits a great variability of lithology and thickness in different parts of the area investigated (fig. 4). It is mainly quartzose sandstone in the Trans Indus Ranges, quartzose, and glauconitic sandstone in western Kohat and parts of Hazara and a mixed quartzose, glauconitic or calcareous sandstone and limestone in Nizampur, Kala Chitta, and southern Hazara.

The thickness is 330 feet in the Trans Indus Ranges, but it thins out eastward and is absent in the main Salt Range. It is 670 feet in western Kohat, 220 feet in Nizampur, 180 feet north of the Haro River and 32 feet in the Kalapani–Kathwal sections of northern Hazara.

The upper age limit of the formation is Lower–Middle Albian in Kohat, Kala Chitta, Hazara and doubtfully so in the Trans Indus Ranges. The lower age limit is more variable. It is regarded doubtfully Aptian in Trans Indus Ranges and more definitely in Western Kohat, Upper Neocomian in Nizampur and Kala Chitta, doubtfully Lower Neocomian in the Haro River sections and Lower Tithonian in Kathwal–Kalapani sections of Hazara (fig. 5).

The formation is overlain disconformably by the Kawaghar Formation of Upper Cretaceous age in Kohat, Nizampur, northern half of Kala Chitta and Hazara. In the Trans Indus Ranges and southern half of Kala Chitta, no Upper Cretaceous rocks are developed, for Lower Tertiary sandy marls and limestone lie disconformably on the Lumshiwal Formation.

Trans Indus Ranges

The lithology consists of fine to medium and some times coarse, light grey or white, quartzose sandstone. The sandstone is massive and current bedded, cliff-forming and in the upper part commonly includes carbonaceous matter. The basal 5 to 10 feet is silty glauconitic shale or siltstone, and contains poorly preserved *Gryphaea* sp. and *Hibolithes* sp. in Baroch Nala outcrops. In the eastern sections of Chichali and Kalabagh no such fauna occurs. The lower contact with the Chichali Formation in the sections west of Chichali Pass is transitional, while towards the east, it is sharp. The upper contact with the Lower Tertiary coal beds is disconformable.

The thickness is 330 feet in the Makerwal area, 125 feet in the Chichali Pass and is practically missing in the Kalabagh section.

Age and Fauna: The formation is unfossiliferous except for some *Gryphaea* in the western sections of the Trans Indus Ranges. Its transitional contact with the underlying Neocomian beds and lithological similarity with the Kohat sections suggest an ?Aptian to Mid-Albian age.

Western Kohat

In the Samana Range section, the formation (641 ft) is divisible into three members. The upper member is a green to reddish brown glauconitic and ferruginous sandstone with a hard (2–6 ft) calcareous sandstone containing abundant fossils including ammonites near the top. The middle member (187 ft) is a light coloured coarse to medium grained current-bedded, massive, quartzose sandstone. The lower member (250 ft) is a thin to medium-bedded, quartzose sandstone with decomposed pyrite and some silty clay partings in the middle part.

In the Darsamand section, the lithology is similar to that of the Samana Range except the thickness is reduced to 550 feet. In Khadimak section no quartzose sandstone is developed. The formation (thickness 670 ft) is represented by dark green to greenish grey glauconitic sandstone and sandy shale with some calcareous and phosphatic interbeds.

Fauna and Age: The topmost hard, dark rusty weathering, calcareous sandstone bed in the Samana and Darsamand sections contains ammonites and other fossil casts. The most common ammonite is *Douvilleiceras mammillatum* (Schlotheim). Other ammonites genera include *Oxytropidoceras, Desmoceras, Cleoniceras, Brancoceras,* and *Lemuroceras.* In addition, poorly preserved brachiopods, bivalves and echinoids occur, which have been figured by Muir Wood, Cox and Currie (1930). The upper age limit in Western Kohat is Lower Albian (Mammillatum Zone). From the Khadimakh section nearly 200 feet below the Mammillatum zone, Aptian ammonites were located. These include *Caspianites* sp. nov. cf. *C. wassillewsky* (Renngarten), *"Ammonitoceras"* sp. cf. *pavlowi* (Vassillievsky), Pseudosaynellid (?*Ailoceras*), Deshayesitids (?Gen. nov. aff. *Dufrenoyia*) (identified by Dr R. Casey of the Institute of Geological Sciences, London).

As no ammonites and other fossils occur in the lower most part, no positive age assignment is possible. From the stratigraphic position above the known Neocomian ammonite—bearing rocks of the Chichali Formation, the lower age limit is very probably Aptian and may extend in some sections (Khadimakh) to Upper Neocomian.

Kala Chitta Nizampur area

When compared with Western Kohat and the Trans Indus Ranges, the Lumshiwal Formation in this area shows a significant facies change and consists of limestone and marl in the upper part and glauconitic and quartzose sandstone in the lower part (fig. 4). The thickness is 155 feet in Wuch khawr section of Nizampur, 190 feet in Western Kala Chitta (south of Sujhanda) and 172 feet in Central Kala Chitta (north northwest of Jhaffar).

The lithology in Wuchkhawr section is as follows:

d. limestone and nodular marls, medium bedded with comminuted shells (bivalves, gastropods) and with a 2 feet hard, nodular, brownish, phosphatic, glauconitic, limestone bed near the top, echinoids and some ammonites (*Oxytorpidoceras* sp.) in the lower part. 40 feet

c. grey to green marly limestone, nodular, thin bedded with echinoids ammonite; Douvilleiceralids and nautiloids in the middle part. 52 feet

b. grey to green, fine silty sandstone, thin bedded, glauconitic, phosphatic, of calcareous towards the top. 36 feet

a. a-3 Coarse glauconitic sandstone
a-2 limestone, sandy, glauconitic with bivalves (*Trigonia* sp.)
a-1 light grey to grey, quartzose sandstone, glauconitic in the upper part with *Trigonia* sp.

Fauna and Age: The lowermost unit (a) in all the sections has yielded *Trigonia* spp., including *Trigonia ventricosa* (Krauss). The uppermost unit (d) is generally poor in recognizable fossils but contain *Oxytropidoceras* sp. and *Neithea attockensis* Cox. Unit c contain Large Douvilleiceralids (Gen. nov.).

The age of the formation may, therefore, range from Upper Neocomian to Lower ?Middle Albian.

Hazara

In Hazara, the Lumshiwal Formation, like the Chichali Formation, shows a significant facies change in the sections lying north and south of the Haro River. In the Jabrian section on the north bank of the Haro River (near Forest Rest House) the lithology is mixed sandstone and limestone similar to the Kala Chitta Range, while in the section further north the formation is mainly sandstone comparable with the "Giumal sandstone" of Spiti. The thickness is 32 feet in Kathwal and 177 feet in the section north of Jabrian Rest House. In the Kathwal–Kalapani sections the formation is mainly quartzose and ferruginous glauconitic sandstone with Lower–Middle Albian fossils in the top calcareous rusty beds and Lower Tithonian fossils from the lowest 6 to 7 feet of the formation.

Fauna and Age: The uppermost 2 to 4 feet of the Lumshiwal Formation in the Kathwal and north of Haro River sections (Jabrian) has yielded Lower–Middle Albian ammonites and other poorly preserved bivalves and gastropods. The ammonites include *Lyelliceras* (abundant), *Oxytropidoceras*, *Mojsisoviczia*, *Dipoloceras*, *Hamites* and *Douvilleiceras*.

From the basal 6 to 7 feet of the highly condensed sequence of the Lumshiwal Formation in Kathwal–Kalapani sections Lower Tithonian ammonites (fig. 5) occur which are described in the present work. These include *Aulacosphinctiodes hazaraensis* sp. nov., *Aulacosphinctoides uhligi* Spath, *Aulacosphinctiodes* sp. indet., *Virgatosphinctes densiplicatus* (Waagen) *Virgatosphinctes frequens* (Oppel). The bivalves include *Trigonia* sp. (small form).

The age of the Lumshiwal Formation is from Lower Tithonian to Lower–Middle Albian in the northern sections (Kathwal–Kalapani) and probably Berriasian to Middle Albian in the Haro River sections. The Berriasian age in the latter areas is considered likely because in the adjoining sections of Murree–Abbottabad Road *Neocosmoceras* has been reported (Pascoe 1959; Spath 1933) to occur in the "Giumal sandstone" (Lumshiwal Formation). The formation in this area appears to be full of non-sequences and represents a highly condensed deposit.

V. FOSSIL LOCALITIES (Text-figs 1–2)

1. *Hazara*

Lower Tithonian and Albian ammonites and other fossils occur in the basal and upper most beds of the Lumshiwal Formation respectively in the Kathwal (lat. 34° 11′ 45″; long. 73° 19′) and Kalapani (lat. 34° 13′; long. 73° 10′ 30″) sections of northern Hazara (fig. 2; 1–2). The underlying Chichali Formation in this area has a few belemnites (*Belemnopsis* sp.) in the basal 2 to 3 feet.

In the section north of Jabrian (lat. 33° 54′ 30″; long. 73° 10′ 30″) in southern Hazara (fig. 2; 3–4), Albian ammonites are commonly distributed in the uppermost 5 feet of the Lumshiwal Formation. One mile south of Jabrian (fig. 2; 5), some Upper Jurassic fragmentary perisphinctid ammonites and belemnites (*Belemnopsis* sp.) occur in the basal 2 to 3 feet of the Chichali Formation.

2. *Kala Chitta Range*

Lower Triassic ammonites are found ½ a mile north of Chak Jabbi Rest House in central Kala Chitta and 1½ miles east of Bagh (lat. 33° 45′ 30″; long. 72° 13′) in Western Kala Chitta (fig. 2, 8).

Lower Jurassic (Toarcian) ammonites occur in the middle part of Datta Formation north of Chak Dalla village (lat. 33° 38′ 50″; long. 72° 23′ 25″) in central Kala Chitta (fig. 2; 6).

Upper Bathonian bivalves in the uppermost beds of Samana Suk Limestone and Upper Jurassic ammonites, belemnites and other fossils in the basal 2 to 3 feet of the Chichali Formation occur in the outcrops of central and Western Kala Chitta Range (fig. 2; 6). The best exposures are found north northwest of Jhallar (lat. 33° 38′ 45″; long. 72° 19′ 15″).

3. *Nizampur*

In the Wuch Khawr section (lat. 33° 46′; long. 72° 2′ 30″), 2 miles south east of Nizampur (fig. 2; 9), Albian and Aptian ammonites and other fossils occur in the upper and middle part and Neocomian bivalves in the basal 10 to 15 feet of the Lumshiwal Formation. In the Mazari Tang section (fig. 2; 10) southwest of Nizampur (lat. 33° 44′; long. 71° 57′ 30″) Upper Jurassic ammonites are distributed in the basal 2 to 3 feet of the Chichali Formation.

4. *Kohat*

The Albian ammonites and other fossils are commonly distributed in the upper 4 to 6 feet of the Lumshiwal Formation in the Samana Range (fig. 2; 11–14), north of Darsamand (fig. 2; 15–17) and north of Thal (fig. 2; 18–18) in Khadimakh Hill. In the Khadimakh section Aptian ammonites and other fossils occur 200 feet below the top Albian fossiliferous bed of the Lumshiwal Formation, while the upper dark rusty brown sandstone members of the Chichali Formation in this section has yielded Berriasian to Valanginian ammonites. In the section west northwest of Darsamand village, rare Upper Cretaceous ammonites occur in the basal 3 feet of the Kawaghar Formation.

5. *Trans Indus Ranges*

The bulk of the ammonites described in the paper comes from the Surghar and Maidan Ranges located between Kalabagh (lat. 32° 59′; long. 71° 32′ 30″) and Makerwal ('at. 32° 56′ 30″; long. 71° 9′) in Mianwali district (fig. 2; 21–27). The Middle Callovian ammonites occur in the outcrops of Samana Suk Limestone (upper bed) between west of Chichali Pass and Makerwal (Datta, Lunda and Punnu mines sections; Baroch nala section). The Upper Jurassic and Neocomian ammonites are distributed in the lower and middle members of Chichali Formation exposed in Maidan and Surghar Ranges and extend eastward in western Salt Range and southward in Shaikh–Budin Hills.

6. *Shaikh Budin Hills*

The Tithonian ammonites were collected from the lower member of Chichali Formation, 2 miles east and west of Shaikh Budin Village (lat. 32° 18′; long. 70° 49′ 45″) in Dera Ismail Khan district (fig. 2; 28–30).

FIG. 5. Fossil locality map of Hazara, Kala Chitta, Kohat, Trans Indus Ranges including Shaikh Budin Hills, West Pakistan.

VI. SYSTEMATIC DESCRIPTIONS

Class *CEPHALOPODA*
Sub-class *AMMONOIDEA*
Order PHYLLOCERATIDA
Superfamily **PHYLLOCERATACEAE**
Family **PHYLLOCERATIDAE** Zittel 1884
Sub-family **CALLIPHYLLOCERATINAE** Spath 1927
Genus ***HOLCOPHYLLOCERAS*** Spath 1927

Holcopyhlloceras silesiacum (Oppel)

(Plate 1)

1865 *Ammonites silesiacus* Oppel: 550
1868 *Phylloceras silesiacum* (Oppel) Zittel: 62, pl. 5, figs 1–7

MATERIAL. One specimen, C.76546.

HORIZON. 20 feet above the base of Chichali Formation, Lower Tithonian.

DESCRIPTION. The specimen is a wholly septate internal mould, 280 mm in diameter. The whorl section is elliptical, much higher than wide, and the umbilicus is very narrow. There are 10 to 12 constrictions per whorl on the internal mould, which are conspicuous near the venter, but weak towards the umbilicus. They are prorsiradiate on the lower half of the whorl side, then bend backwards to become rursiradiate on the upper part of the whorl.

DIMENSIONS. C.76546–280: 165 (59), 95 (34), 30 (11).

REMARKS. The specimen is comparable with Spath's figure (1927; pl. VI, fig. 2b) of *H.* aff. *polyolcum* (Benecke) from the Kimmeridgian beds of Cutch, but the style of constrictions and suture line are different. Spath's figured specimen has a less elevated whorl section.

LOCALITY. Chichali Pass, Trans Indus Ranges.

Genus *PTYCHOPHYLLOCERAS* Spath 1927

Ptychophylloceras ptychoicum (Quenstedt)

(Plate 2, figs 1a, b)

1847 *Ammonites ptychoicus* Quenstedt: 219, pl. 17, fig. 12.
1875 *Phylloceras ptychoicum* (Quenstedt) Waagen: 30, pl. VII, figs 2a–c.
1927 *Ptychophylloceras ptychoicum* (Quenstedt); Spath: 46 (see for synonymy).

MATERIAL. One specimen, C.76547.

HORIZON. Lower part of lower member (about 10 feet above the base) of the Chichali Formation, Lower Kimmeridgian.

DESCRIPTION. The specimen is involute, inflated, wholly septate and about

66 mm in diameter. The whorl section has sub-parallel whorl sides and a broadly arched venter, and the umbilicus is very narrow. There are 6 labial ridges per half whorl at 66 mm diameter, which are well developed on the venter and ventral shoulder, but fade out on the whorl sides, and are not seen on the inner whorl.

Dimensions. C.76547–66: 38 (58), 32 (48), —.

Remarks. This specimen is very similar to Waagen's figure from the Katrol Beds of Cutch; from *P. tithonicum* Spath (1927, : 48, pl. V, fig. 9) it is distinguished by its more compressed whorl section.

Locality. Punnu Mines, Trans Indus Ranges.

Order LYTOCERATIDA
Superfamily **LYTOCERATACEAE**
Family **LYTOCERATIDAE** Neumayr 1875
Sub-family **LYTOCERATINAE** Neumayr 1875
Genus ***PTEROLYTOCERAS*** Spath 1927
Pterolytoceras exoticum (Oppel)
(Plate 2, figs 2a, b)

1863 *Ammonites exoticus* Oppel: 278, pl.76, figs 5a–c.
1903 *Lytoceras exoticum* (Oppel) Uhlig: 114, pl. I, figs 3a–d, 4a–c (see also for synonymy).
1939 *Pterolytoceras exoticum* (Oppel); Spath: 7 (see for discussion).

Material. One specimen and two doubtful fragments C.76548–50.

Horizon. Near the base of the middle and upper part of the lower member of the Chichali Formation, Upper Tithonian–Berriasian.

Description. The complete specimen is very evolute, the outer whorl hardly touching the inner one, and is 91 mm in diameter. Nearly half of the outer whorl is body-chamber. The whorl section is sub-circular, wider than high. The ornamentation consists of very fine, ridge-like, crinkled costae, which are distant on septate whorls, but closer on the body-chamber; they are rectiradiate or gently prorsiradiate on the whorl side and venter. Between them are finer and denser ribs or lirae. The shell is thin and internal moulds are smooth.

Dimensions. C.76548–90: 32 (36), 34 (38), 40 (44).
C.76548–64: 22 (34), 25 (39), 28·5 (45).

Remarks. These specimens resemble closely in ornamentation and dimensions Uhlig's figure from Chidamu, Spiti area, but they have slightly more inflated shells with a greater whorl height and whorl thickness at comparative diameters.

The two poorly preserved fragmentary specimens from the Samana Range are wholly septate.

Localities. Chichali Pass (C.76548), Trans Indus Ranges, and south of Fort Lockhart, Samana Range (C.76549–50).

Pterolytoceras sp. indet.

(Plate 2, figs 3a, b)

MATERIAL. Three specimens, C.76551–3.

HORIZON. Basal part of the middle member and upper part of the lower member of the Chichali Formation, one fragment from the lower part of the rusty brown sandstone member of the Chichali Formation at Khadimakh; Upper Tithonian–Berriasian.

DESCRIPTION. The figured specimen is a smooth, wholly septate internal mould of approximately 180 mm in diameter. The whorl section is sub-oval near the aperture, higher than wide, but half a whorl before it is sub-circular, slightly wider than high. The umbilicus is wide, the umbilical wall is steep and the umbilical edge is rounded.

DIMENSIONS. C.76551–180: 64 (35), 60 (33), 80 (44) (all approx.).

REMARKS. One of these specimens occurs in the same bed as *P. exoticum* (Oppel) described above. The overall whorl shape and suture line compare favourably with *P. exoticum* (Oppel), which on Uhlig's figured specimen from the Spiti area (1910: pl. I, fig. 3a, b) has a complete body chamber with dorsal extensions at the apertural end at about 80·0 mm diameter, and occupies nearly half of the outer whorl.

In its large size, the figured specimen may be compared with *Hemilytoceras rex* (Waagen) (1875 : 36, pl. VII, fig. 1). Waagen's species has similar whorl proportions (at 660 mm: 220 (36), 200 (33), 230 (39)), but shows different ornamentation. The whorl section, however, is very similar.

LOCALITIES. South west of Malla Khel, Trans Indus Ranges; South of Fort Lockhart, Samana Range; Khadimakh.

Order AMMONITIDA

Superfamily **HILDOCERATACEAE**

Family **HILDOCERATIDAE** Hyatt 1867

Subfamily **BOULEICERATINAE** Arkell 1950

Genus ***BOULEICERAS*** Thevenin 1906

Bouleiceras nitescens Thevenin

(Plate 3, figs 1a, b, 3a, b)

1906 *Bouleiceras nitescens* Thevenin: 171, figs 1–3.
1908 *Bouleiceras nitescens* Thevenin: 13, pl. 11, figs 6 (lectotype designated by Arkell 1952), 11.
1952 *Bouleiceras nitescens* Thevenin; Arkell, p. 261.

MATERIAL. Three specimens, C.76554–6.

HORIZON. Middle member of Datta Formation, Lower Toarcian.

DESCRIPTION. The larger fragmentary septate specimen (C.76555) is smooth, and has a rectangular whorl section which is much higher (75 mm) than wide (51 mm).

The whorl sides are flat and parallel. The venter is unicarinate and fairly broad. The suture line includes a three to four pronged asymmetrical, fairly deep, first lateral lobe.

The smaller specimen (C.76554) is more typical of the species. It is evolute, of roughly 58 mm diameter, and has a sub-rectangular whorl section, higher (21 mm) than wide (?18 mm). The whorl sides are sub-parallel, and gradually convergent towards a rather broad unicarinate-bisulcate venter. The inner whorl (up to a diameter of approximately 43 mm) has two rows of strong, sharp spine-like tubercles on the ventral and umbilical shoulders. The outer whorl has rounded, smooth rursiradiate ribs which curve forwards obliquely and are weakly tuberculate at the umbilical edge. Some ribs bifurcate at the umbilical edge.

Remarks. The larger septate fragment has a similar suture-line to Arkell's figured specimen of *B.* sp. indet. from Jebel Tuwaiq (1952 : 263, fig. 5 (1); pl. xv, fig. 1). In its large size and partly in suture it is comparable with Thevenin's (1908: pl. ii, fig. 11) of *B. nitescens*. The smaller specimen is very similar to the lectotype designated by Arkell (Thevenin 1908 : pl. II, fig. 6).

The specimen figured by Arkell (1952: 260, fig. 4) from Jebel Tuwaiq, Arabia, as *B. nitescens* has a more compressed and comparatively much higher than wide whorl section, which is convergent to a narrow, keeled venter. The ventral shoulders are not as distinct as in the lectotype or the Kala Chitta specimen. It appears that Arabian forms are closer in whorl section to Thevenin's (1908) pl. ii, figs 8 and 10, which Arkell (1952) designated as *B. elegans* Arkell (with weaker tubercles).

Locality. Chakdalla, Kala Chitta Range.

Bouleiceras chakdallaense sp. nov.

(Plate 3, figs 2a, b, 4)

Diagnosis. Evolute, whorl section sub-rectangular, slightly wider than high on inner whorl, and higher than wide on outer whorl. Venter unicarinate-bisulcate. Shell with two rows of thick bullate tubercles.

Holotype. C.76557.

Material. Two septate fragmentary specimens, C.76557–8.

Horizon. Middle member of Datta Formation, Lower Toarcian.

Description. Both specimens are wholly septate, and up to 92 mm in diameter. The whorl section is sub-rectangular with sub-parallel whorl sides and a unicarinate-bisulcate venter. There are two rows of prominent bullae at the umbilical and ventral shoulders which become thick and blunt on the outer whorl. The suture line consists of two or three pronged first lateral lobes and rounded saddles.

Dimensions. C.76557–92: 30 (33), 30 (33), 44(48).
C.76557–64: 19 (30), 22 (34), 30 (47).

Remarks. The strong tumid tubercles of this species are comparable with those of *B. tumidum* Arkell (1952 : 261; also Thevenin 1908 : pl. II, fig. 9, lectotype), but it differs distinctly in whorl section, evolution and the persistence of two rows or tubercles at a larger diameter.

Locality. Chakdalla, Kala Chitta Range.

Bouleiceras sp. indet.

Material. Three specimens, C.76559–61.

Horizon. Middle member of Datta Formation, Lower Toarcian.

Description. The larger fragmentary specimen (C.76561) has a smooth, septate, fairly compressed and involute shell. The whorl section is much higher than wide. The whorl sides are convergent towards a rather narrow unicarinate venter.

Remarks. The specimen resembles, in side view and suture line, Arkell's figure of *B. nitescens* Thevenin from Jebel Tuwaiq (Arkell 1952 : 260, fig. 4). In its tall compressed whorl section, the specimen may also be compared with *B. elegans* Arkell (Thevenin : 1890, pl. II, figs 8 and 10). It is also comparable with *B.* aff. *nitescens* Thevenin from Hazara (Davies and Gardezi 1965).

Locality. Chakdalla, Kala Chitta Range.

Superfamily **HAPLOCERATACEAE**

Family **HAPLOCERATIDAE** Zittal 1884

Genus ***HILDOGLOCHICERAS*** Spath 1924

Hildoglochiceras sp. indet.

(Plate 3, fig. 5)

Material. One specimen, C.76562.

Horizon. 20 feet above the base of Chichali Formation, Lower Tithonian.

Description. The whorl section is much compressed with whorl sides converging towards a bluntly keeled venter. There is a spiral furrow at the middle of whorl side which first appears at about 18 mm diameter and becomes distinct and fairly deep at diameters greater than 28·5 mm. In cross section the ventral side of the furrow is shallow, but the umbilical side is deep and steeply inclined. The inner whorls are smooth, but at 22 mm diameter weak, crescent-shaped rursiradiate ribs appear on the ventral side of the spiral furrow.

Dimensions. C.76562–28·5: 12 (42), 6 (21), 8·5 (30).

Remarks. The specimen differs from *Hildoglochiceras latistrigatum* (Uhlig) (1903 : 27, pl. II, fig. 4; pl. III, fig. 5) in being more compressed, having a higher whorl section, showing earlier appearance of crescent-shaped costae, and lacking a distinct spiral furrow on the earlier whorls. In the earlier appearance of costae and the later appearance of the spiral furrow it is more like specimens of *Hildoglochiceras kobelli* (Oppel) figured by Uhlig (1903 : 25, pl. LVII, figs 3a–b, 4a–d) and Waagen (1875 : 72, pl. XIII, figs 11–12) from middle Katrol sandstone of Cutch. It differs, however, in being more compressed and in having a shallower spiral furrow. Spath (1939 : 124, pl. XVIII, figs 8a, b) figured a specimen from the Trans Indus Ranges as *Hildoglochiceras* sp. indet. (group of *H. propinoum* Waagen) but considered it to be worn and probably derived. The present form differs from Spath's species in whorl shape and ornamentation. The external mould is attached to the whorl side of an *Aulacosphinctoides* (group of *A. uhligi* Spath) and suggests a close association of the two genera.

Locality. West of Makerwal, Trans Indus Ranges.

Superfamily **STEPHANOCERATACEAE**

Family **MAYAITIDAE** Spath 1928

Genus ***MAYAITES*** Spath 1924

Mayaites cf. ***waageni*** (Uhlig) sp. indet.

(Plate 3, figs 6a, b, 7a, b)

1910 *Macrocephalites waageni* Uhlig: 270, pl. LXXVII, figs 1–3.
1933 *Mayaites waageni* (Uhlig); Spath: p. 804.

Material. Two specimens, C.76563–4.

Horizon. Basal 3 inches of Chichali Formation, Upper Oxfordian.

Description. The specimens are involute, septate, and 30 and 51 mm in maximum diameter respectively. The whorl section is subcircular, slightly wider than high on the inner whorls, but higher than wide at larger diameters. The umbilicus is narrow and deep. The ribs are strong and gently sinuous, and three secondary ribs intervene between each primary rib. There are 16 to 17 primary ribs at 30 mm diameter on C.76563 and 18 to 19 at 24 mm diameter on C.76564.

Dimensions. C.76563–30: 15 (50), 15·5 (52), 7·5 (25);
C.76563–24: 11 (46), 12 (50), 6 (25).
C.76564–51: 20·5 (40), 20 (39), ?15·5 (30);
C.76564–24: 11 (46), 11·5 (48), 7 (29).

Remarks. In size, ornamentation and involution the specimen compares favourably with *M. waageni* (Uhlig) and is less close to *M. kitcheni* (Uhlig) from the Upper Oxfordian of Spiti. It differs in being less inflated, more evolute and in having a narrower, less elevated whorl section.

Locality. Punnu Mines, Trans Indus Salt Ranges.

Superfamily **PERISPHINCTACEAE**

Family **REINECKEIIDAE** Hyatt 1900

Genus ***REINECKEIA*** Bayle 1878

Reineckeia anceps (Reinecke)

(Plate 4, figs 1a, b, 2a, b, 3a, b)

1818 *Nautilus anceps* Reinecke: 82, pl. VII, fig. 61.
1846 *Ammonites anceps* (Reinecke); d'Orbigny: 462, pl. 166.
1876 *Reineckeia anceps* (Reinecke); Bayle: pl. LVI, figs 1?, 2, 3.
1881 *Reineckeia anceps* (Reinecke); Steinmann: 284
1928 *Reineckeia anceps* (Reinecke); Spath: 255, pl. XLIV, fig. 6a–c (see for discussion).

MATERIAL. Seven specimens, C.76565–71.

HORIZON. Upper one foot of Samana Suk Limestone, Middle Callovian.

DESCRIPTION. The specimen C.76565 is evolute, septate and 50 mm in diameter. The whorl section is cadiconic, much depressed, with a broadly arched venter and a mid-ventral groove. The umbilicus is wide and shallow, and the umbilical wall is rounded. There are two to three oblique, deep constrictions on all visible whorls. Weak primary ribs on the umbilical wall terminate at strong conical tubercles on the side of the whorl. Three or four secondary ribs issue from each tubercle and cross the venter with interruption at the shallow mid-ventral sulcus. Occasional ribs are intercalated and not joined to tubercles. The rib preceding a constriction is weakly tuberculate, while the rib following the constriction on the apertural side is non-tuberculate.

There are 14 or 15 tubercules on the outer whorl of C.76565. Specimen C.76568 differs in being less evolute, having four constrictions on its last whorl, a narrow ventral groove and greater number of tubercles at a comparative diameter.

DIMENSIONS. C.76565–48: 13 (27), 22 (46), 24 (50).
C.76568–60: 16 (27), 24 (40), 22 (37).

REMARKS. The specimen C.76565 compares very closely in ornamentation and depressed whorl section, to the inner whorls of the specimens figured by d'Orbigny and Bayle. It is similar in whorl shape and ornamentation to the small septate specimen figured by Spath (1928) from Neidlingen, Wurttemburg.

LOCALITIES. Lunda Mines (C.76565–69) and Punnu Mines (C.76570–71), Trans Indus Ranges.

Reineckeia cf. ***torulosus*** (Spath)

(Plate 4, figs 4a, b)

1933 *Reineckeites torulosus* Spath: 679, pl. CXXVII, figs 5, 6, 11; pl. CXXVIII, figs 1, 8.

MATERIAL. Four specimens C.76572–5.

HORIZON. Upper one foot of Samana Suk Limestone, Middle Callovian.

DESCRIPTION. The shell is evolute, septate and approximately 113 mm diameter. The whorl section is oval, higher than wide, with subtabulate, grooved venter. The

umbilicus is wide and the umbilical wall is steeply inclined. Weak ribs on the umbilical wall are surmounted by radially elongate tubercles on the lower third of whorl side. Three or four straight, prorsiradiate ribs issue from each tubercle and are interrupted along the mid-venter.

Dimensions. C.76572–?113: 44·5 (39), 26 (32), 44 (39).

Remarks. The species was described by Spath (1933) from the Anceps Beds of Cutch. It is placed here in *Reineckeia* because of its prominent lateral tubercles and bundles of 3 or 4 secondary ribs.

Localities. West of Makerwal (C.76572), and Lunda Mines (C.76573–5), Trans Indus Ranges.

Reineckeia sp. indet.

Material. Five specimens, C.76576–80.

Horizon. Upper 2 feet of Samana Suk Limestone, Middle Callovian.

Description. The specimen C.76576 is worn, evolute and approximately 120 mm in diameter. The worl section is rounded with equal height and thickness. The umbilicus is wide and the umbilical wall is steep. Some constrictions are present.

Distant, rectiradiate ribs are surmounted by tubercles on the lower third of the whorl side. 4 or 5 rectiradiate to slightly prorsiradiate ribs issue from each tubercle and are interrupted at the mid-venter.

Remarks. In its smooth venter, evolute shell, and rounded whorl section, C.76576 is comparable with *Reineckeia brancoi* Steinmann (1881 : 285, text-figure 4), but differs in ornamentation. In *R. brancoi* there are frequently non-tuberculate trifurcating and bifurcating ribs along with tuberculate bundled ribs. The specimen C.76578 has coarse ribs which resemble *R. arthritica* (J. de C. Sowerby) as figured by Spath (1928, pl : XXXIII, figs 2a–b) from Cutch.

Localities. Lunda Mines (C.76576–7), and south of Malla Khel (C.76578–80), Trans Indus Ranges.

Family **PERISPHINCTIDAE** Steinmann 1890

Sub-family **PROPLANULITINAE** Buckman 1921

Genus ***OBTUSICOSTITES*** Buckman 1921

Obtusicostites buckmani Spath

(Plate 4, figs. 5a, b; Plate 5, figs 1a, b, 2a, b)

1875 *Perisphinctes obtusicostata* Waagen: 147, pl. XXXVIII, figs 3a, b only.

1931 *Obtusicostites buckmani* Spath: 300, pl. LIII, figs 3a–b (paratype); pl. LXII, fig. 8 (see for synonymy).

Material. Four specimens, C.76581–4.

Horizon. Uppermost 1½ feet of Samana Suk Limestone, Middle Callovian.

Description. The specimen C.76584 may be a microconch for it shows the beginning of body chamber and uncoiling of the last whorl at the apertural end at 75 mm diameter. The other two specimens are septate, and C.76583, of 135 mm diameter, appears may be a macroconch. The whorl section is rounded and slightly wider than high. The umbilical wall is smooth and almost vertical, and the umbilical edge is rounded. The ribs are strong, rectiradiate to gently prorsiradiate, and bifurcate or trifurcate at about the middle of the whorl side. The rib counts are as follows:

C.76581—15 primary ribs at 66 mm diameter.
C.76583—23 primary ribs at 135 mm diameter, 20 at 98 mm.
C.76584—15 or 16 primary ribs at 75 mm diameter.

Dimensions. C.76581– 52: 20 (38), 24 (46), 19 (37).
C.76583–120: 46 (38), 42 (35), 42 (35).
C.76584– 73: 27 (37), 29 (40), 27 (37).

Remarks. C.76581 closely resembles the holotype figured by Waagen (1875, pl. XXXVIII, fig. 3). The specimen C.76583 resembles, in ornamentation and dimensions, Spath's paratype (1931 : pl. LIII, figs 3a–b) from Upper Anceps–Lower Athleta Beds of Cutch. The species differs from *O. obtusicosta* (Waagen) in having longer and less strong and blunt, nontuberculate primary ribs and the persistence of strong secondary ribs on the body chamber.

Locality. Punnu Mines, Trans Indus Ranges.

Obtusicostites sp. indet.

Material. Seven specimens, C.76585–91.

Horizon. Upper 2 feet of Samana Suk Limestone, Middle Callovian.

Remarks. The fragments C.76585–6 and C.76588 show coarse primary ribs branching into two to four secondary ribs low on the whorl side. In ribbing and whorl section, C.76585–6 are like *O. buckmani* Spath and *O. ushas* Spath (1931: pl. LIII, fig. 1a–b; pl. LVI, fig. 1). C.76588 also resembles *O. buckmani* Spath, but its blunt primary ribs splitting into 3 to 4 secondary ribs are like those of *O. obtusicosta* (Waagen) (1875 : pl. XXXVIII, figs 1a–b). C.76591 is crushed but shows coarse primary ribs (19 to 20 per whorl at 94 mm diameter) dividing into 3 secondary ribs near the middle of whorl side. The approximate dimensions are: 94 mm: 39 (41), 27 (29), 30 (32). This specimen may also belong to *O. buckmani* Spath though the straight secondary ribs resemble *O. devi* Spath (1931: pl. LIV, figs 1a–b) and *O. waageni* Spath (1931: pl. LIII, figs 2a–b) from Cutch.

Localities. Lunda Mines (C.76585–90), and Datta Mines (C.76591), Trans Indus Ranges.

Genus ***HUBERTOCERAS*** Spath 1930

Hubertoceras sp. indet.

(Plate 5, figs 3, 4a, b, 5a, b, 6)

MATERIAL. Three incomplete body chamber specimens and 10 fragments, C.76592–C.76604.

HORIZON. Upper 2 feet of Samana Suk Limestone, Middle Callovian.

DESCRIPTION. The four figured specimens and most of the fragments are body chambers, and C.76597 shows a lateral lappet. Moderately strong rectiradiate to gently prorsiradiate primary ribs bifurcate or rarely trifurcate in the upper third of the whorl side. Occasionally the secondary ribs are intercalatory and the primary ribs simple. The whorl section is oval and higher than wide, with a rounded venter. The umbilicus is rather narrow and the umbilical wall is steep.

DIMENSIONS. C.76592–41: 16·5 (40), 14 (34), 12·5 (30).
C.76595–42: 16 (38), 14 (33), 15 (36).
C.76597–57: 22 (39), 14 (25), 20·5 (30).

REMARKS. Spath (1931) described and figured a number of *Hubertoceras* species and their variants from Lower Athleta and Anceps Beds of Cutch. In view of the poor preservation and fragmentary nature of the Trans Indus specimens, it is not possible to assign them to any of the species of Waagen and Spath from Cutch. The Trans Indus species show some variations in ribbing, whorl thickness and involution but are generally more involute and smaller in size than the Cutch forms. They are from one locality and horizon.

The figured specimen C.76595 (Plate 5, figs 5a, b) can be compared in whorl section and ornamentation with *H. dhosaense* (Waagen) (Spath 1931: 319), but differs in having additional intercalatory ribs and in being more involute. The specimen C.76597 (Plate 5, fig. 6) compares favourably in compressed whorl section with *H. mutanus* (Waagen) (Spath 1931: 318), but differs in details of ornamentation.

LOCALITY. Lunda Mines, Trans Indus Ranges.

Sub-family **PSEUDOPERISPHINCTINAE** Schindewolf 1925

Genus ***CHOFFATIA*** Siemiradzki 1898

Choffatia sp. indet.

MATERIAL. Three fragments, C.76605–7.

HORIZON. Upper 2 feet of Samana Suk Limestone, Middle Callovian.

DESCRIPTION. The specimen C.76605 is evolute and wholly septate, with a whorl height of 33 mm and whorl thickness of 27 mm. The primary ribs are long, rectiradiate or gently prorsiradiate, and bifurcate near the ventral shoulder. Occasionally there is one short intercalatory rib between the bifurcating ribs. The secondary ribs are weak and interupted on the mid-venter. C.76607 has more convex whorl sides and coarser, distant primary ribs.

Remarks. The poor preservation does not allow close comparison with any species of the genus. C.76605 is comparable in ornamentation and whorl section with *C. sakuntla* Spath (1931: 351, pl. LXIII figs 4a–b), but has a more evolute shell. C.76607 show some resemblance in coarse, blunt primary ribs with *C. cobra* (Waagen).

Locality. South south west of Malla Khel (Baroch nala), Trans Indus Ranges.

Sub-family **PERISPHINCTINAE** Steinmann 1890

Genus ***PHOSOSPHINCTES*** Schindewolf 1925

Prosophinctes (?) ***virguloides*** (Waagen)

(Plate 6, figs 1, 2a, b)

1875 *Perisphinctes virguloides* Waagen: 203, pl. XLIX, figs 1a–b.
1925 *Perisphinctes virguloides* Waagen; Spath: 122.
1931 *Prososphintes virguloides* (Waagen); Spath: 441, pl. LXX, fig. 3; pl. XC, fig. 4 (see for synonymy).
1932 *Perisphinctes virguloides* Waagen; Lanquine: 635.
1934 *Prososphinctes virguloides* (Waagen); Spath: 12, pl. I, figs 3, 4a–b, 6 (holotype); pl. II, figs 3, 4a–b; pl. IV, figs 5a–b; pl. V, fig. 7.

Material. Twelve specimens, C.76608–19.

Horizon. Basal one foot of Chichali Formation, Upper Oxfordian.

Description. The specimens are wholly septate and up to 88 mm in diameter. The whorl section is oval, with flat sides. Shallow constrictions parallel to the rib direction can be seen on the 88 mm diameter specimen but are absent on the other specimens. Long primary ribs bifurcate at the ventro-lateral shoulder; there are 28 primary ribs per half whorl at 88 mm diameter on C.76609, and 53 or 54 on C.76608 at 81 mm diameter.

Dimensions. C.76608–81: 25 (31), —, 39 (48).
C.76609–88: 28 (32), 24·5 (28), 36·5 (41).

Remarks. This species was placed in the genus *Perisphinctes* by Spath (1925), Dietrich (1925 : 19) and Lanquine (1932 : 635). Later, Spath (1931 : 441; 1934 : 12) put it into *Prososphinctes* and assigned to it an Upper Oxfordian to Lower Kimmeridgian age in Cutch, and an Upper Oxfordian, Transversarium Zone, age in Kala Chitta. Spath (1934: pl. I, fig. 6) refigured Waagen's holotype, which shows strong and sharp prorsiradiate ribs with pronounced forward projection on venter. The specimen figured here is Pl. 6, fig. 1, from Mazari Tang, Nizampur, is very similar in ornamentation and dimensions to the holotype.

Spath (1934 : pl. II, fig. 4) figured another specimen from Kala Chitta which is more involute, and considered it to be the best example of the species. The incomplete specimen figured here in Pl. 6, fig. 2, also from Mazari Tang, is similar, and differs from the holotype in being more involute and in having a greater whorl height.

P. virguloides is doubtfully referred to the genus *Prososphinctes*, for it shows strong sharp ribbing, has weak or no constrictions, and occurs in the Upper Oxfordian,

Transversarius Zone of Kala Chitta and Mazari Tang. *Prososphinctes* is regarded by Arkell (1957) as Lower Oxfordian in age, and the type species, *Perisphinctes mazuricus* Bukowski, 1887, has weak, dense ribs, prominent constrictions and less distinct bifurcation. Arkell (1937 : 1) also did not agree with Spath's inclusion of *P. virguloides* in *Prososphinctes*.

Locality. Mazari Tang, Nizampur, and north north-west of Jhallar, Kala Chitta.

Genus ***PERISPHINCTES*** Waagen 1869

Perisphinctes sp. indet.

(Plate 6, figs 3a, b)

Material. Two specimens C.76622–3, from Mazari Tang and two, C.76620–1 from Trans Indus Ranges.

Horizon. Basal bed of Chichali Formation, Upper Oxfordian.

Description. The inner whorls of specimen C.76622 from Mazari Tang are similar to those of C.76620 from Trans Indus Ranges. The whorls are depressed and the dense prorsiradiate ribs bifurcate on the upper part of the whorl then cross the venter with slight forward arching. Some ribs are simple. Distinct constrictions are present. The outer whorl of C.76622 has distant coarse ribs.

Dimensions. C.76620–35: 9·5 (27), 11 (31), 11·3 (32).

Remarks. In the dense prorsiradiate ribbing and presence of constrictions, the Mazari Tang specimen, C.76622, compares favourably with the holotype of *Perisphinctes jelskii* (Siemiradzki) (Spath, 1934: 6, pl. V, figs 6a–b) and with other specimens from the Transversarium Zone of the Attock district figured by Spath (1934: 6, pl. IV, figs 2–4).

Localities. Mazari Tang, Nizampur (C.76622–3); north of Kalabagh, Trans Indus Ranges (C.76620–1).

Subgenus ***KRANAOSPHINCTES*** Buckman 1921

Perisphinctes (Kranaosphinctes) sp. indet.

(Plate 6, figs 4a, b)

Material. Four specimens, C.76624–27.

Horizon. Basal bed of Chichali Formation, Upper Oxfordian.

Description. The figured specimen, C.76624, is very evolute, wholly septate and 100 mm diameter. The whorl section is rounded, slightly wider than high, and

the whorl sides are nearly flat. Two constrictions (one deep) are seen on the outer whorl. The strong, straight, prorsiradiate ribs are moderately distant, and bifurcate high on the whorl side near the ventral shoulder. There are a few intercalated secondary ribs on the final third of the last whorl and a very few ribs remain simple throughout. The ribs are much reduced, or almost effaced, at the middle of the venter. C.76624 has about 48 primary ribs at 100 mm diameter.

Dimensions. C.76624–100: 24, 25, 59.

Remarks. The species is similar in its evolute whorls, ornamentation and rib density to the inner whorl of *P.* (*K.*) *cymatophorous* (Buckman) figured by Arkell (1939: pl. XXXVII, figs 3a–b), but differs in dimensions. In dimensions, rib density and whorl section it also compares with *P.* (*K.*) *trifidus* (J. Sowerby) as figured by Arkell (1939 : pl. XXXVI, fig. 2a–b), but shows more irregular trifurcation of the ribs.

Localities. Chichali Pass (C.76624), north of Kalabagh (C.76625), Trans Indus Ranges; north north west of Jhallar (C.76626–7), Kala Chitta Range.

Subgenus ***ARISPHINCTES*** Buckman 1924

Perisphinctes (Arisphinctes) orientalis Siemiradzki

1875 *Perisphinctes plicatilis* (J. Sowerby); Waagen: 189, pl. LI, figs 2a–b; pl. LII, fig. 3
1891 *Perisphinctes orientalis* Siemiradzki: 289.
1931 *Perisphinctes orientalis* Siemiradzki; Spath: 416, pl. LXIX, fig. 1; pl. LXXII, fig. 2; pl. LXXIV, figs 3a–b (see for synonymy).
1934 *Perisphinctes orientalis* Siemiradzki; Spath: 4, pl. IV, figs 1a–b.

Material. One specimen, C.76627.

Horizon. Basal one foot of Chichali Formation, Upper Oxfordian.

Description. The shell is evolute, wholly septate and 190 mm diameter. The whorl section is rounded quadrate, higher than wide, but depressed on the inner whorls. The ribs are moderately dense on the inner whorls, becoming gradually more distant and coarse on the outer whorl. They are prorsiradiate, bifurcate near the ventral shoulder and are gently arched forwards on the venter. There are occasional short intercalatory ribs. Near the aperture, the ribs fade out on the mid-venter and many are simple. There are about 47 ribs at 190 mm diameter. Some shallow constrictions occur especially on the inner whorls.

Dimensions. 190: 52 (27), ?46 (24), 102 (54).

Remarks. This is a worn incomplete specimen, very similar in ornamentation, rib density and whorl section to the Kala Chitta and Cutch specimens figured by Spath, but differs in dimensions and in having a higher than wide whorl section at comparative diameters.

Locality. Mazari Tang, Nizampur.

Subgenus ***DICHOTOMOSPHINCTES*** Buckman 1926

Perisphinctes (Dichotomosphinctes) cf. ***rotoides*** Ronchadze

(Plate 7, figs 1a, b, 2)

1917 *Perisphinctes rotoides* Ronchadze: 11, pl. I, fig. 8.
1938 *Perisphinctes* (*Dichotomosphinctes*) *rotoides* Ronchadze; Arkell: 90, pl. XVI, figs 1–7.

MATERIAL. Five fragments, C.76629–33.

HORIZON. Basal 4 inches of Chichali Formation, Upper Oxfordian.

DESCRIPTION. These are septate fragments with evolute, quadrate whorls, the whorl section being higher (20·5 mm) than thick (18·5 mm). Strong rectiradiate or slightly prorsiradiate ribs are separated by wider interspaces. They bifurcate high on the whorl side near the ventral shoulder and are straight or slightly arched forwards across the venter. Occasional simple ribs occur. There are prominent deep constrictions parallel to the ribs.

REMARKS. These Trans Indus fragmentary specimens compare well in ornamentation, whorl section, evolute shell and in the presence of deep constriction with Arkell's figures of *P.* (*D.*) *rotoides* from the Plicatilus Zone of England. They also compare with *P.* (*D.*) *antecedens* Salfield as figured by Arkell (1938 : pl. XVI, fig. 8).

LOCALITY. Chichali Pass, Trans Indus Ranges.

Perisphinctes (?Dichotomosphinctes) sp. indet.

(Plate 7, fig. 3a, b)

MATERIAL. Two fragments, C.76634–35, from Trans Indus Ranges, and C.76636 from the Kala Chitta Range.

HORIZON. Basal 3 inches (Trans Indus Ranges) or basal one foot of Chichali Formation Upper Oxfordian.

REMARKS. These fragmentary specimens indicate the presence of one or more species of *Dichotomosphinctes* in the collections. They have dense, prorsiradiate ribs which bifurcate high on whorl side close to the ventral shoulder, and cross the venter with slight forward arching. At small diameters, the whorl height is less than whorl thickness, but the outer whorl is more compressed. Spath (1934: 11, pl. III, figs 5a–b; pl. VI, figs 3a–c) figured specimens from Kala Chitta similar to C. 76636 as *P.* (*Dicholomosphinctes*) aff. *grossouvrei* (Siemiradzki). The Trans Indus specimens are somewhat different, and resemble *P.* (*D.*) *Jacki* Spath (1931: pl. LXXIII, fig. 6) and *P.* (*D.*) *subhelenae* Spath (1931: pl. CI, figs 2, 4a–b) in ribbing and whorl section.

LOCALITIES. Chichali Pass, C.76634, and Punnu Mines, C.76635, Trans Indus Range; north north west of Jhallar, C.76636, Kala Chitta Range.

Sub-family **VIRGATOSPHINCTINAE** Spath 1923

Genus ***KATROLICERAS*** Spath 1924

Katroliceras cf. ***pottingeri*** (J. de C. Sowerby)

(Plate 7, figs 4a, b)

1840 *Ammonites pottingeri* J. de C. Sowerby: 719, pl. LXI, fig. 10.
1931 *Katroliceras pottingeri* (J. de C. Sowerby); Spath: 505, pl. LXXXIII, fig. 4; pl. XCV, figs 6, 7; pl. XCVIII, fig. 4; pl. CII, figs 5a–d (see for synonymy).

MATERIAL. One fragment, C.76637.

HORIZON. 6 to 7 feet above the base of Chichali Formation, Lower Kimmeridgian.

DESCRIPTION. The specimen is septate, and has a sub-coronate whorl section, with a broad, gently arched venter. The whorl height is 44 mm, the thickness approximately 60 mm. Distant, massive ribs are separated by broad interspaces. They branch near the umbilical shoulder into about three ribs which cross the venter with forward arching. There is a swelling at the point of branching. Occasionally one of the ventral ribs is intercalated.

REMARKS. This specimen closely resembles, in ribbing and whorl section the example *K. pottingeri* (J. de C. Sowerby), from the Middle Katrol beds of Cutch, figured by Spath (pl. CII, figs 5a–b; pl. LXXXIII, fig. 4). It also resembles the very closely allied species, *K. pingue* Spath (1933: pl. LXXXII, figs 1a–b) from a similar horizon in Cutch.

LOCALITY. Punnu Mines, Trans Indus Ranges.

Katroliceras sp. indet.

MATERIAL. Three specimens, C.76638–40.

HORIZON. 5 to 7 feet above the base of Chichali Formation, Lower Kimmeridgian.

REMARKS. The specimens are small and septate with the following dimensions:
C.76639–25: 8·5 (34), 12 (48), 12·5 (50).
C.76638–20·5: 7 (34), 10 (49), 9 (44).

They may represent the inner whorls of forms like *K. depressum* Spath (1931: 515, pl. LXXXIX, figs 4a–b) or *K. zitteli* Spath (1931: 513, pl. LXXXVII, figs 6a–b). It is possible that the species is the inner whorls of *Pachysphinctes* which also has a depressed whorl section and similar ornamentation at a comparative diameter.

LOCALITIES. Datta Mines (C.76638) and north of Kalabagh (C.76639–40), Trans Indus Ranges.

Genus ***PACHYSPHINCTES*** Dietrich 1925

Pachysphinctes robustus Spath

(Plate 7, figs 5a, b)

1931 *Pachysphinctes robustus* Spath: 491, pl. LXXXIV, fig. 5; pl. XCIII, figs 10a–b.

MATERIAL. Three specimens, C.76641–3.

HORIZON. 5 to 7 feet above the base of Chichali Formation, Lower Kimmeridgian.

DESCRIPTION. These are evolute, septate fragments up to 135 mm diameter. The whorl section is sub-quadrate, wider than high, with greatest thickness on the lower third of the whorl side. The strong, rectiradiate or gently prorsiradiate ribs are separated by deep interspaces two to three times as wide on the outer whorl, but inner whorls are more densely ribbed. They bifurcate high on the whorl side at a small blunt tubercle. Occasionally ribs remain simple (about 2 per half whorl), and a few indistinct trifurcating ribs appear near the aperture. The ribs are arched forwards on the venter and weaken along the siphonal line.

DIMENSIONS. C.76641–135: 40 (30), 42 (31), 68 (50).

REMARKS. The figured specimen is similar in whorl section, dimensions and ornamentation to Spath's holotype from Cutch. The other fragments are comparable to *P. robustus* Spath, and also to the allied species *P. major* Spath (1931 : 489) and *P. bathyplocus* (Waagen) (Spath 1931 : 493) in whorl section and ornamentation. *P. robustus* Spath is very closely allied in ornamentation and whorl section to *P. major* Spath.

LOCALITIES. Punnu Mines (C.76641–3), Trans Indus Ranges.

Genus *AULACOSPHINCTOIDES* Spath, 1923

Aulacosphinctoides hazaraensis sp. nov.

(Plate 8, figs 1a, b, 2a, b)

DIAGNOSIS. Evolute, depressed whorls, with distant, prorsiradiate coarse ribs that bifurcate and occasionally trifurcate just ventral of the middle of the whorl side. Slight mid-ventral depression. 3 or 4 well marked constrictions per whorl.

MATERIAL. Two specimens, C.76644—the holotype, and C.76645—the paratype.

HORIZON. Basal bed of Lumshiwal Formation ("Giumal Sandstone"), Lower Tithonian.

DESCRIPTION. The holotype consists of a complete body chamber, probably of an immature specimen, two-thirds of a whorl long and 83 mm maximum diameter. The mouth-border is flared especially on the venter, and is preceded by a constriction, and there is a constriction at the beginning of the body chamber. The paratype consists of half a specimen, 63 mm diameter, showing parts of 3 whorls. The final third of the outer whorl is body chamber. In both specimens, the whorl section is rounded and depressed, and there is a slight mid-ventral depression. The ribs are almost straight prorsiradiate and strong; the holotype has 17 or 18 ribs per half whorl at 83 mm diameter, the paratype 17 ribs per half whorl at 63 mm. On the outer third of the whorl, the ribs bifurcate or sometimes trifurcate on the outer whorls, then pass straight across the venter and are partly interrupted at the mid-ventral depression. There are 3 or 4 deep constrictions per whorl parallel to the ribs.

DIMENSIONS. C.76644–75: 25 (33), 32·5 (43), 43·5 (46).
C.76645–62: 20·5 (33), 26 (42), 27 (44).

REMARKS. Uhlig (1910) described a number of *Aulacosphinctoides* species from the Himalayas. This new species compares well with *A. infundibulus* (Uhlig) (1910 : pl. LXVI, fig. 3; pl. LXXII, figs 1–4) and *A. hundesianus* (Uhlig) (1910: pl. LXXI, fig. 3; pl. LXXII, fig. 2; pl. LXVI, fig. 4) in ribbing, whorl section and dimensions, but differs in having coarser, less dense and more commonly trifurcating ribs on the outer whorl at comparative sizes. In the presence of frequent and fairly prominent constrictions, it is close to *A. hundesianus* (Uhlig), but differs in ornamentation details. *A. infundibulus* (Uhlig) has 41 to 44 ribs at 83 mm diameter, while the new species (which has a complete body-chamber at 83 mm) has about 34 to 36 primary ribs. *A. hundesianus* (Uhlig) has about 46 to 48 primary ribs at the same size.

LOCALITY. Kathwal, Hazara.

Aulacosphinctoides uhligi Spath

(Plate 8, figs 3a, b)

1910 *Perisphinctes* (*Aulacosphinctes*) *torquatus* (J. de C. Sowerby); Uhlig: 368, pl. LXIX, figs 2a–d; pl. LXXI, figs 1a–d, 2a–c.
1923 *Aulacosphinctoides uhligi* Spath: 299.
1939 *Aulacosphinctoides* aff. *uhligi* Spath: 120, pl. XV, figs 8a–b.

MATERIAL. Two specimens, C.76646–7.

HORIZON. Two feet above the base of Lumshiwal Formation ("Giumal Sandstone") in Hazara and 20 feet above the base of Chichali Formation in the Trans Indus Ranges, Lower Tithonian.

DESCRIPTION. The shell is evolute, septate and 62 mm in diameter. The whorl section is rounded, sub-circular on the outer whorl, but depressed and with flatter whorl sides on the inner whorls. The ribs are prorsiradiate and bifurcate at the middle or slightly higher on the whorl side. On the inner whorls, the bifurcation point is higher, near the ventral shoulder. There are 23 ribs per half whorl at 62 mm diameter, and slightly more on the inner whorls. There are two oblique constrictions on the outer whorl, and the one at the apertural end appears to mark the beginning of the body chamber. The constrictions cut across several secondary ribs immediately preceding them. The rib following a constriction is simple.

DIMENSIONS. C.76646–62: 20 (32), 22·5 (36), 29·5 (48).
C.76646–21: 7 (33), 12 (57), 10 (47).

REMARKS. The figured specimen compares well in ornamentation and dimensions with the type specimens of *A. uhligi* Spath (1923 : 299; 1933 : 476) which were figured by Uhlig (1910: 368, pl. 69, fig. 2; pl. 71, figs 1, 2). In the Himalayas it is quite common at various localities. The change from depressed inner to elevated outer whorls, and the change of the bifurcation point from the ventral shoulder on

the inner whorl to lower on the side of the outer whorl, compares well with Uhlig's illustrations. It differs, however, in having a smaller number of primary ribs. It is distinguished from *A. infundibulus* (Uhlig) by its straight, prorsiradiate ribs, bifurcating higher on the whorl side and more compressed whorl section. It is like *A. willisi* (Uhlig 1910: pl. LXXIII, figs 1a–c) in ornamentation, but differs in whorl section and other details. The fragmentary specimen described by Spath (1939) from the Trans Indus Ranges as *A.* aff. *uhligi* Spath is also similar.

Localities. Kathwal, Hazara, and a doubtful fragment from the Trans Indus Salt Ranges.

Aulacosphinctoides sp. indet.

(Plate 8, figs 4a, b)

Material. Four specimens, C.76648–51.

Horizon. One foot above the base of Lumshiwal Formation ("Giumal sandstone"), Hazara, and 20 feet above the base of Chichali Formation, Trans Indus Ranges, Lower Tithonian.

Description. The figured specimen has a maximum diameter of 78 mm; slightly more than half of the outer whorl is body chamber, the last septum occurring at 57 mm diameter. The whorl section is well rounded and depressed, and has a shallow mid-ventral groove. The ribs are prorsiradiate, bifurcating high on the whorl side, then pass straight across the venter, but are weakened along the siphonal line. On the last whorl trifurcating ribs are dominant, but near the aperture the ribbing becomes irregular and simple. There are 35 ribs at 57 mm diameter. There are two oblique, moderately deep constrictions on the septate whorls, which cut across the ribs preceding them. The rib following a constriction is simple.

Dimensions. C.76648–57: 28 (35), 25 (44), 22·5 (39).

Remarks. In whorl section, straight ribs and deep constrictions, this species resembles *Aulacosphinctoides willisi* (Uhlig 1910: pl. LXV, figs 3c–d; pl. LXXIII, figs 1a–c), but differs in having frequent trifurcating ribs on the outer whorl. Uhlig's species is based on a mature adult specimen of 84 mm diameter, which has a lappet, but on the body chamber only two out of 22 to 23 primary ribs trifurcate, the rest bifurcate. Contrary to this, in the present specimens more than 75% of the ribs trifurcate on the outer half whorl. In the trifurcating ribs it resembles *A. hazaraensis* sp. nov., but is more involute, has finer straight ribs and a deeper umbilicus. The three other specimens (C.46649–51) of *Aulacosphinctoides* are indeterminate due to poor preservation. They have very evolute shells, depressed whorl sections and dense, fine ribs.

Localities. Kathwal (C.76648), Hazara; Chichali Pass (C.76649), Shaikh Budin Hills, (C.76650–51), Trans Indus Ranges.

Genus *VIRGATOSPHINCTES* Uhlig 1910

Virgatosphinctes denseplicatus (Waagen)

(Plate 8, figs 5a, b)

1875 *Perisphinctes denseplicatus* Waagen: 201, pl. XLVI, figs 3a–b; pl. LV, fig. 1a–b.
1910 *Perisphinctes* (*Virgatosphinctes*) *denseplicatus* Waagen; Uhlig: 313, pl. LIII, figs 3a–d; pl. LIV, figs 1a–c; pl. LV, figs 1a–d, 2a–d, 3a–d; pl. LVI, figs 1a–c.
1933 *Virgatosphinctes densplicatus* (Waagen); Spath: 532, pl. LXXVII, figs 3a–c; pl. XC, fig. 1; pl. XCVI, figs 3a–b; pl. CII, fig. 4 (see for synonymy).

MATERIAL. Two specimens, C.76652–3.

HORIZON. Basal part of Lumshiwal Formation ("Giumal sandstone"), Hazara, and 20 feet above the base of Chichali Formation, Trans Indus Ranges, Lower Tithonian.

DESCRIPTION. The figured specimen is wholly septate and 57 mm diameter. The outer whorl embraces half to two-thirds of the previous whorl. The whorl section is rounded and slightly wider than high. The sharp, dense ribs are prorsiradiate, bifurcate near the middle of the whorl side, and cross the venter arched slightly forwards. There are a few shallow constrictions parallel to the ribs, and they are followed by a simple rib. The rib density is 50 at 57 mm diameter.

DIMENSIONS. C.76652–57: 22 (39), 23·5 (41), 21 (37).

REMARKS. This specimen has ribbing typical of *V. denseplicatus* (Waagen) and compares closely with Spath's figure of an evolute form of the species *V. rotunda* Spath (1933: pl. CII, fig. 4) from the lower Umia group of Cutch and with Uhlig's figure of the inner whorls of *V. denseplicatus* (Waagen) from Spiti area (Uhlig 1910: pl. LIII, figs 3a–c; pl. LXV, figs 2a–d). It differs primarily in having slightly less dense ribbing than Uhlig and Spaths' specimens.

LOCALITIES. Kathwal, Hazara (C.76652), west of Makerwal, Trans Indus Ranges (C.76653).

Virgatosphinctes frequens (Oppel)

(Plate 9, fig. 1a, b)

1865 *Ammonites frequens* Oppel: 295, pl. 87.
1910 *Perisphinctes* (*Virgatosphinctes*) *frequens* (Oppel), Uhlig: 325, pl. LXIII, figs 1a–c, 3a–c; pl. LXXXV, figs 1a–c; pl. LXXV A, figs 1a–c (see for synonymy).

MATERIAL. Three specimens, C.76654–6.

HORIZON. Lower 2 to 3 feet of Lumshiwal Formation, Giumal sandstone, Lower Tithonian.

DESCRIPTION. The figured specimen is evolute and 98 mm in diameter. The whorl section is oval with sides that converge towards a rather narrow venter. The ribs are prorsiradiate, moderately distant on the outer whorl, but more dense on the inner whorls. They bifurcate or trifurcate near the middle of whorl side, then the

fine secondary ribs recurve to cross the ventral shoulder and the venter radially. There are 56 or 57 primary ribs at 98 mm diameter.

DIMENSIONS. C.76654–98: 33 (34), 31 (32), 42 (43).

REMARKS. The figured specimen resembles strongly, in ornamentation, Oppel's holotype and other specimens figured by Uhlig (1910) from the Spiti area. It differs in being more evolute and in having a less inflated and elevated whorl section. It has almost identical dimensions to *Virgatosphinctes subfrequens* Uhlig (1910: 327, pl. XLIX, figs 1a–d; pl. LXI, figs 1a–d). One of the two fragmentary specimens, C.76655, is more inflated and appears to be closer in dimensions to Oppel's holotype. *V. frequens* was recorded from different localities in Hazara by Middlemiss (1896 : 33–34) and Spath (1933 : 804). It is the most abundant *Virgatosphinctes* in northern Hazara and occurs in association with *Aulacosphinctoides*. One fragment from 20 feet above the base of Chichali Formation in the Makerwal area is doubtfully assigned to this species and is also associated with *Aulacosphinctoides*. Arkell (1956 : 407) similarly pointed out the close association of these two genera in the Middle Spiti shales of Himalaya.

LOCALITIES. Kathwal–Kalapani (C.76654–5), Hazara, one fragment from Makerwal, Trans Indus Ranges (C.76656).

Virgatosphinctes sp. indet.

MATERIAL. One specimen, C.76657.

HORIZON. 2 feet above the base of Lumshiwal Formation ("Giumal sandstone"), Lower Tithonian.

REMARKS. The specimen has strong, sharp and dense ribs which cross the venter transversely. The ribs usually bifurcate from the middle of whorl side, but a few trifurcate and there are occasional simple ribs on the inner whorls. It has part of the body chamber on which the ribs trifurcate in a virgatome fashion and are more distant. Dimensions are: 72: 28 (39), 29 (40), 23·5 (33). It is comparable with *V. subquadratus* Uhlig (1910: pl. LXVIII, figs 1a–c) and *V. indistinctus* Uhlig (1910: pl. LXVI, figs 2a–b) in whorl section and ornamentation, but is more involute and has denser ribs.

LOCALITY. Kathwal, Hazara.

Family **ASPIDOCERATIDAE** Zittel 1895
Sub-family **ASPIDOCERATINAE** Zittel 1895
Genus ***EUASPIDOCERAS*** Spath 1931
Euaspidoceras cf. ***wagurense*** (Spath)

1931 *Neaspidoceras wagurense* Spath: 614, pl. CXX, figs 7a–d (see for synonymy).

MATERIAL. One fragment, C.76658.

HORIZON. Basal one foot of Chichali Formation, Upper Oxfordian.

DESCRIPTION. The specimen is evolute with a sub-rectangular whorl section; whorl height 42 mm and thickness 39 mm at the aperture. The whorl sides converge gradually towards a broad sub-tabulate venter. Two rows of tubercles at the umbilical edge and ventral shoulder are connected by weak, blunt ribs. The umbilical tubercles extend rursiradially on the umbilical wall. The tubercles on the ventral shoulder are obliquely elongated.

REMARKS. The specimen is poorly preserved, but closely resembles, in ornamentation and whorl section Spath's figure of a specimen from the Kantcote sandstone (Bimammatum Zone) of Cutch. It may also be compared with *E. varians* Spath (1931: pl. CV, figs 7a–b ; pl. CX, figs 1a–b) from the same horizon in Cutch, but differs in having a less compressed whorl section and arched whorl sides.

LOCALITY. Mazari Tang, Nizampur.

Genus ***ASPIDOCERAS*** Zittel 1868

Sub-genus ***ASPIDOCERAS*** Zittel 1868

Aspidoceras (Aspidoceras) sp. indet.

MATERIAL. One specimen, C.76659.

HORIZON. 5 to 7 feet above the base of the Chichali Formation, Lower Kimmeridgian.

DESCRIPTION. The specimen is involute, probably septate, and approximately 56 mm diameter. It has a subcircular whorl section, wider than high. There is a distinct row of tubercles near the umbilical shoulder, and a suggestion of an indistinct row of outer tubercles on the side of the inner whorl. There are no ribs.

DIMENSIONS. C.76659–56: 25 (45), 30·5 (54), 61 (29).

REMARKS. In inflated shell and weak outer row of tubercles, the species may be compared with *A.* (*A.*) *iphiceroides* (Waagen) (Spath, 1931: 635, pl. CXXIII, figs 8a–b). In dimensions it is similar to a small example from Mombasa described by Spath as *A.* (*A.*) *mombasense* (Spath 1931 : 636). The whorl section is very similar to a form from Cutch figured by Spath (1931: pl. CXXII, fig. 9) as *A.* (*Aspidoceras*) sp. indet.

LOCALITY. Punnu Mines, Trans Indus Ranges.

Sub-genus ***PSEUDOWAAGENIA*** Spath 1931

Aspidoceras (Pseudowaagenia) sp. indet.

(Plate 9, figs 2a, b)

MATERIAL. One specimen, C.76660.

HORIZON. One foot above the base of Chichali Formation, Lower Kimmeridgian.

DESCRIPTION. The shell is half involute, septate, and 36 mm diameter. The whorl section is oval and higher than wide. There are no ribs. There are 15 to 16 small, rounded tubercles at the umbilical shoulder at 36 mm diameter.

DIMENSIONS. C.76660–36: 16 (44), 15 (42), 10 (28).

REMARKS. The suture line of this specimen is very similar to that of *Pseudowaagenia hyanaldi* (Neumayr) and *Pseudowaagenia micropla* (Oppel) as figured by Spath (1933: pl. CXVIII, fig. 11; pl. CXXII, fig. 30) from Cutch. Spath (1933: 623, pl. CXXII, figs 3a–c) figured a specimen of *P. micropola* (Oppel) from the lower Katrol beds of Cutch, which had dimensions of 55 mm: 42%, 36%, compared with 55 mm: 40%, 25%, 33%, in Oppel's type. The specimen described here is distinguished from both Neumayr's and Oppel's species in being more involute and more inflated.

LOCALITY. Punnu Mines, Trans Indus Ranges.

Genus ***PHYSODOCERAS*** Hyatt 1900

Sub-genus ***SIMASPIDOCERAS*** Spath 1925

Physodoceras (Simaspidoceras) sp. indet.

MATERIAL. One fragment, C.76661.

HORIZON. About one foot above the base of Chichali Formation, Lower Kimmeridgian.

DESCRIPTION. This fragment has a rounded, trapezoidal whorl section, with greatest thickness just above the umbilical shoulder, and a broad venter. The umbilicus is narrow. There are weak ribs and weak blunt tubercles near the umbilical shoulder.

REMARKS. The weak ribs, umbilical tubercles, broadly rounded venter and squarish whorl section, may be compared with *Simaspidoceras argobbae* Dacque (1905). The suture line also compares well with Dacque's species.

LOCALITY. Punnu Mines, Trans Indus Ranges.

Sub-family **SIMOCERATINAE** Spath 1924

Genus ***HYBONOTICERAS*** Breistroffer 1947

Hybonoticeras sp. indet.

MATERIAL. One fragment, C.76662.

HORIZON. 5 feet above the base of Chichali Formation, Lower Kimmeridgian.

DESCRIPTION. This is a septate fragment, with a sub-rectangular whorl section and nearly flat whorl sides. There is a deep sulcus in the middle of the venter, bordered by sharp ridges. The ornamentation consists of very weak, distant rectiradiate or gently prorsiradiate ribs. These swell into blunt, thick tubercles at

the umbilical shoulder and again on the whorl side near the ventral shoulder. The ventral tubercles tend to be clavate while the umbilical tubercles are obliquely elongated backwards and extend partly on to the umbilical wall.

Remarks. The species is comparable in weak ribs, size, side and ventral views with *Hybonoticeras kachensis* (Spath) from Lower–Middle Katrol beds of Cutch (Spath 1933 : 645, pl. CXXII, fig. 6), and with *H. pressulum* (Neumayr) and *H. ciliatum* Berckhemer and Holder, both figured by Berckhemer and Holder (1959: pl. I, fig. 1; pl. II, fig. 6, pl. 3, fig. 9). The suture line is comparable with a specimen figured by Spath (1933: pl. XCV, fig. 2) as *H.* sp. nov. aff. *hybonata* (Oppel) from Lower Katrol beds of Cutch.

Locality. East of Chichali Pass (Kutch Mines), Trans Indus Ranges.

Family **OLCOSTEPHANIDAE** Haug 1910
Sub-family **SPITICERATINAE** Spath 1924
Genus ***PRONICERAS*** Burckhardt 1919
Proniceras indicum Spath
(Plate 9, figs 3a, b)

1939 *Proniceras indicum* Spath: 34, pl. III, figs 4a–d.

Material. One specimen, C.76663.

Horizon. 25 to 30 feet above the base of Chichali Formation, Lower Tithonian.

Description. This specimen is an almost complete immature of 38 mm diameter. The whorl section is almost circular. The prorsiradiate ribs bifurcate near the middle of the whorl side, and cross the venter as forwardly-directed chevrons, but are weak at the mid-ventral line. There are a few simple ribs on the outer whorl. There are about 50 ribs per whorl at 38 mm diameter. Three moderately deep oblique constrictions per whorl are present on outer and inner whorls. The rib following each constriction is simple.

Dimensions. C.76663–38: 15 (39), 15 (39), 14 (37).

Remarks. The specimen is very similar to Spath's holotype which was based on a fragmentary specimen, 19 mm in diameter, from the Trans Indus Salt Range.

Locality. Chichali Pass, Trans Indus Salt Ranges.

Genus ***SPITICERAS*** Uhlig 1903
Spiticeras multiforme Djanelidze
(Plate 9, figs 4a, b)

1922 *Spiticeras multiforme* Djanelidze: 143, pl. VII, figs 3a–b; pl. XV, figs 1a–c, 2a–c; pl. XX figs 1a–c; pl. XXII, figs 3a–b.

Material. One specimen, C.76664.

HORIZON. 3 feet below the base of the middle member of the Chichali Formation, Upper Tithonian.

DESCRIPTION. This is a wholly septate specimen, of approximately 66 mm diameter. The whorl section is oval with greatest breadth near the umbilicus. There are 16 or 17 prominent, umbilical tubercles on the outer whorl. Prorsiradiate ribs issue from the tubercles in bundles of 4 or 5 and pass over the venter arched forwards. Occasional ribs bifurcate higher up on the side of the whorl, and some ribs are intercalated. The ribs weaken along the mid-ventral line. There are an estimated 105 ribs on the final whorl.

REMARKS. This specimen is almost identical in dimensions and ornamentation with Djanelidze's figure (Pl. VII, figs 3a–b) of a specimen from France. It also compares well with *Spiticeras bilobatus* (Uhlig) and *Spiticeras subbilobatus* (Uhlig) (1910 : 96, 98, pl. X, figs 1a and 2) in ornamentation, side and ventral views. It however, shows more elevated whorl section, denser ribs, less evolute shell and absence of prominent constrictions.

LOCALITY. South west of Malla Khel, Trans Indus Ranges.

Spiticeras sp. indet.

MATERIAL. Two fragments, C.76665–6.

HORIZON. 3 feet below the base of the middle member of the Chichali Formation, Upper Tithonian.

REMARKS. These fragments are characterized by strong forwardly projected ribs on the upper half of the whorl side and acute forward chevrons on the venter. There are prominent radially elongated tubercles at the umbilical shoulder. In ribbing style and strong forward projection of the ribs they compare well with *Spiticeras* aff. *scriptus* (Strachey) (Uhlig, 1910 : 112, pl. XIV, figs 3a–d) from Lochambelkichak, Spiti area. They, however, differ in whorl section, and Uhlig's form has a less acutely rounded venter.

LOCALITY. South west of Mallakhel, Trans Indus Ranges.

Sub-family **PROVALANGINITINAE** nov.

Genus ***PROVALANGINITES*** nov.

TYPE SPECIES. *Provalanginites rhodesi* sp. nov.

DIAGNOSIS. Involute, inflated sphaerocones, with an eccentrically coiled and contracted adult body-chamber of 40–60 mm maximum diameter. Whorl section depressed, semicircular, with an occluded umbilicus on septate whorls and a very narrow eccentric umbilicus on the body-chamber. Adult body-chamber occupies about seven-eighths of a whorl. Ribs moderately dense, simple, or bifurcating and

trifurcating from the middle of the whorl side, but fading towards umbilical shoulder. Ribs prorsiradiate on side of whorl and venter. Suture line fairly simple with multifid asymmetric first lateral lobe and retracted suspensive lobe.

Remarks. The species recalls the sphaerocone–cadicone shells and eccentric coiling of the earlier families Tulitidae (Middle Jurassic) and Oecoptychidae (Middle Callovian to Lower Oxfordian), and the later family Olcostephanidae, especially the type species, *Ammonites nuculeus* Roemer (Koenen 1902 : pl. IV, figs 6–7) of the genus *Valanginites* (Upper Valanginian). The sub-family Provalanginitinae nov. is characterized by sphaeroconic, involute, eccentrically coiled shell, with weak, non-tuberculate ribs. It may include the genus *Valanginites* and range from Tithonian to Valanginian.

In the Trans Indus Ranges the two new species of the genus and sub-family occur in the Tithonian beds of the Chichali Formation.

Provalanginites rhodesi sp. nov.

(Plate 10, figs 1a, b, 3a, b)

Diagnosis. Moderately-sized species, adult body chamber of 45–50 mm diameter. Inner whorls sphaeroconic, body chamber eccentrically coiled, contracted. Ribs simple or bifurcating, smooth near umbilical shoulder, but becoming strong and forwardly arched on venter.

Material. Three specimens; C.76671, the holotype, and C.76672–73, paratypes.

Horizon. 20 to 30 feet above the base of the Chichali Formation, Lower Tithonian.

Description. The holotype has most of its body chamber complete, only the final quarter whorl is missing; its maximum diameter is 44 mm. Both paratypes are wholly septate, and of 29 and 25 mm diameter. The septate whorls are depressed sphaerocones with the umbilicus occluded. The venter of the adult body chamber uncoils away from the spiral of the previous whorl, so that the umbilicus opens slightly; the body chamber also contracts markedly towards the aperture. The mouth border is not preserved.

The ribs are fairly dense on inner whorls, but stronger on the body-chamber. They are simple, bifurcating or occasionally trifurcating, and are weak near the umbilicus. They are strongly prorsiradiate, and cross the venter arched forwards. There are an estimated 45–46 ribs per whorl at 44 mm diameter.

Dimensions. C.76671–44: 24 (55), 27 (61), 4·5 (10).
C.76671–34: 18 (53), 27 (79), 2·5 (7).
C.76672–21: 11 (52), 18 (86), 0·0 (0).

Remarks. The species resembles in eccentric coiling and sphaerocone shell the type species of Callovian genus *Kheraiceras* and the Lower Oxfordian genus *Protophites*, but differs in details of coiling, whorl section and ornamentation.

In eccentric coiling and sphaerocone shell, it resembles more closely *Valanginites nucleus* (Roemer) (Koenen, 1902: pl. IV, figs 6–7) from the Valanginian beds of Europe, but differs in ornamentation details. The genus *Valanginites* is restricted (Wright, 1957) to the Upper Valinginian.

Localities. Lunda mines (C.76671), and Chichali Pass (C.76672–73), Trans Indus Ranges.

Provalanginites howarthi sp. nov.

(Plate 10, figs 2a, b)

Diagnosis. Larger than *P. rhodesi*, adult body chamber being 52 mm diameter, septate whorls sphaetoconic but more depressed, ribs almost absent on whorl sides and less strong on the venter than in *P. rhodesi*.

Material. One specimen C.76674, the holotype.

Horizon. About 25 feet above the base of Chichali Formation, Lower Tithonian.

Description. The single specimen is a complete adult, with a body chamber seven-eighths of a whorl long, which coils eccentrically on the venter, contracts in whorl thickness half way along the body chamber, then flares slightly at the aperture. Some of the mouth border is preserved on the venter. The inner whorls are sphaeroconic and very depressed although only the final part of the last septate whorl can be seen. The sides of the body chamber are smooth, weak ribs being confined to the venter where they arch gently forwards, and appear to fade along the mid-ventral line.

Dimensions. C.76674–52: 23 (44), 32 (62), ?6 (12).

Remarks. The species differs from *Provalanginites rhodesi* sp. nov. in having weaker ornament, smoother body-chamber, a more depressed whorl section and a broader venter.

Locality. Punnu Mines, Trans Indus Ranges.

Family **BERRIASELLIDAE** Spath 1922

Sub-family **BERRIASELLINAE** Spath 1922

Genus ***BLANFORDICERAS*** Cossman 1907

Blanfordiceras cf. ***wallichi*** (Gray)

(Plate 10, figs 4a, b, 5a, b)

1832 *Ammonites wallichi* Gray: Pl. C, fig. 3.

1910 *Hoplites* (*Blanfordia*) *wallichi* (Gray); Uhlig: 186, pl. XXXI, figs 1a–c, 2; pl. XXIX, figs 1a–b, 2a–b, 3a–c; pl. XXX, figs 1a–c.

1939 *Blanfordiceras* aff. *wallichi* (Gray); Spath: 43, pl. IV, fig. 6; pl. V, figs 1, 9, 10 (see for synonymy).

Material. Three fragments, C.76675–7.

HORIZON. 10 to 60 feet below the base of the middle member of the Chichali Formation, Upper Tithonian.

DESCRIPTION. The whorl section is sub-quadrate, higher than wide, with a tabulate venter that has a marked sulcus in the middle. Strong, gently sinuous and prorsiradiate ribs, bifurcate near the middle of the whorl side. A few ribs are simple. The ribs are high and sharp on the venter and are interrupted by the sulcus. On the body-chamber, the ribs tend to cross the venter with only slight degeneration along the mid-venter.

REMARKS. These fragmentary specimens broadly resemble the examples of *Blandfordiceras wallichi* (Gray) figured by Uhlig (1910). In the Spiti area the species has been reported from both the upper and middle shales, suggesting a long time range in the Tithonian. In the Trans Indus Ranges, it is found above the *Aulacosphinctoides* horizon, and as high as the *Himalayites* and *Spiticeras* beds.

LOCALITIES. North of Kalabagh, Chichali Pass, Punnu Lunda Mines, and south west of Malla Khel, Trans Indus Ranges.

Blanfordiceras cf. ***latidomus*** (Uhlig)

(Plate 10, figs 6a, b, 7a, b)

1910 *Hoplites* (*Blanfordia*) *latidomus* Uhlig: 196, pl. XXXV, figs 1a–c.
1939 *Blanfordiceras* aff. *latidomus* (Uhlig); Spath: 46, pl. V, figs 12a–b.

MATERIAL. Two specimens, C.76678–9.

HORIZON. About 20 feet below the base of the middle member of the Chichali Formation, Upper Tithonian.

DESCRIPTION. These evolute, wholly septate specimens have sub-quadrate or polygonal whorl sections, with whorl thickness equalling whorl height, and sulcate venters. The ribs are prorsiradiate, sharp, fairly distant, and bifurcate at the middle of the whorl side; the point of bifurcation being marked by a small, sharp tubercle. They are sharp and elevated on the venter and are interrupted by the sulcus. A few ribs remain simple.

DIMENSIONS. C.76678–?47: 16 (34), 17 (36), 18 (38).
C.76679–36: 13 (36), 13 (36), 14 (39).

REMARKS. The specimens resemble, in whorl shape and ornamentation, Uhlig's holotype from Lochambelkichak, Spiti area. They are wholly septate and of smaller size, but all of them show the sharp tuberculation on the middle of the whorl side, and rather straight prorsiradiate ribs.

LOCALITY. Lunda Mines, Trans Indus Ranges.

Blanfordiceras sp. indet.

(Plate 10, figs 8a, b)

MATERIAL. Four fragments, C.76680–83.

HORIZON. 2 to 3 feet above the base of Chichali Formation in Kala Chitta, and

10 to 30 feet below the base of middle member of Chichali Formation in the Trans Indus Ranges, Upper Tithonian.

Remarks. These fragments may belong to one or more species of the genus. Poor preservation does not allow a specific determination. C.76680 has a rounded whorl section, ribs that bifurcate near the middle of whorl side and the point of bifurcation is marked by radially elongated blunt tubercles. The ribs are interrupted at the mid-venter but are without any prominent tuberculation. In ventral view and whorl section it resembles a small inner whorl fragment figured by Spath (1930 : pl. IV, fig. 5; pl. V, fig. 2,; pl. VI, figs 5, 11, 12 and 15) as *Blanfordiceras* cf. *boehmi* (Uhlig). C.76681 has a higher than wide whorl section, sharp fairly distant prorsiradiate ribs, sharp tubercles at the point of bifurcation on whorl side and at the termination of ribs on the grooved venter. The fragment may be compared in ribbing and higher than wide whorl section with *B. acuticosta* (Uhlig 1910 : 301, pl. XXXVIII, figs 2a–c).

Localities. Chichali Pass and Kalabagh, Trans Indus Ranges (C.76682–83), and north north west of Jhallar, Kala Chitta Range (C.76680–81).

Genus ***PROTACANTHODISCUS*** Spath 1923

Protacanthodiscus cf. ***michaelis*** (Uhlig)

(Plate 11, figs 1a, b)

1902 *Hoplites michaelis* Uhlig: 35, pl. VII, figs 1–4.

Material. One fragment, C.76684.

Horizon. 3 feet below the base of the middle member of the Chichali Formation, Upper Tithonian, just below *Subthurmnnia fermori* horizon.

Description. A detached fragment of the body chamber has a rectangular whorl section with a broadly rounded venter, whorl height of 61 mm and breadth of 38 mm. It has only very weak ribs, but prominent umbilical and ventrolateral tubercles and weak lateral ones. The septate part of the specimen (as figured) has a more compressed whorl section, with flat sides and a flat sulcate venter. The ribs are strong and nearly straight, and they branch at the middle of the whorl side at the lateral tubercle. Occasional ribs branch from an umbilical tubercle, and there are frequent non-tuberculate simple ribs. There are prominent umbilical tubercles, smaller mid-lateral tubercles, and all the ribs swell into blunt transverse tubercles at the ventral shoulder and are interrupted at the mid-ventral sulcus.

Dimensions. C.76684–?96: 36 (38), 24 (25), ?38 (40).

Remarks. The specimen compares well with *Hoplites michaelis* Uhlig in whorl section and general ornamentation, but differs in having frequent intercalatory ribs, less frequent bifurcation from the umbilical shoulder, transverse rather than oblique ventral tubercles and greater forward projection of the ribs. It is also similar to forms like *Berriasella chaperi* (Pictet, 1868 : 242, pl. 37, fig. 3; Mazenot, 1939: 80, pl. VIII, figs 5–9, pl. IX, figs 1a–b), *Berriasella aspera* Mazenot (1939: pl. IX,

figs 2–3) and *Berriasella malbosi* (Pictet, 1863: 77, pl. XIV, figs 1–2; Mazenot, 1939 : 98, pl. XIII, figs 8a–c; pl. XIV, fig. 1). *B. chaperi* attains a diameter of about 150 mm, and at 63 mm has the following dimensions (Mazenot, 1939 : 81): whorl height 36%, whorl thickness 23%, umbilical width 38%. All these species have prominent tubercles and tabulate venters and are closer to *Protacanthodiscus* than to *Berriasella*.

This specimen has great stratigraphic importance in the area, for it lies just below the zone of *Subthurmannia fermori* and close to the Jurassic/Cretaceous boundary.

Locality. Lunda Mines, Trans Indus Ranges.

?*Protacanthodiscus* sp. indet.

(Plate 11, figs 4a, b)

1939 *Himalayites*? (Gen. nov.) ?sp. indet. Spath: 66, pl. VII, figs 1a–c.

Material. One specimen, C.76685.

Horizon. Five feet below the base of the middle member of the Chichali Formation, Upper Tithonian.

Description. The specimen is wholly septate, with a hexagonal section and a sulcate venter. The ribs are concave forwards, mainly simple, but some bifurcate at the lateral tubercle. At the ventro-lateral edge, they swell into high, thin tubercles which form chevrons along the sides of the ventral sulcus. Prominent, radially elongated tubercles occur sporadically on some simple and all bifurcating ribs at the middle of the whorl side.

Remarks. This specimen is provisionally placed in the genus *Protacanthodiscus* because of its fairly broad venter, large size and presence of mid-lateral and ventro-lateral tubercles. It differs from the type species and other species of *Protacanthodiscus* in details of ribbing and in having a *Himalayites*-type hexagonal whorl section. In ornamentation and forward projection of ribs near the ventral shoulder, it is closer to *Raimondiceras*, e.g. *R. raimondi* (Arkell and Wright 1957 : 351) and *R. ?salinarium* Spath (1939 : 62, pl. XIV, figs 4, 5), but differs in ventral aspects, whorl section and its less dense ribs. In whorl section and the forward projection of the ribs near the venter, it recalls the Valanginian species *Neohoploceras baumbegeri* Spath (1939: pl. XXII, figs 3a–b). It strongly resembles a form described and figured by Spath from the Trans Indus Ranges as *Himalayites*? (Gen. nov.?) sp. indet. (1939: pl. VII, fig. 1a–c), except that Spath's form is more inflated and has a few trifurcating ribs.

The specimen incorporates the whorl section of *Himalayites*, the tabulate, broad venter of *Protacanthodiscus*, and the forward projection of ribs on the ventral shoulder of *Raimondiceras*. It probably represents a new Tithonian genus, intermediate between *Protacanthodiscus* and *Raimondiceras* which could have given forms like *Kilianella* and *Neohoploceras* during Berriasian and Valanginian times.

Locality. Lunda Mines, Trans Indus Ranges.

Sub-family **HIMALAYITINAE** Spath 1925

Genus ***HIMALAYITES*** Uhlig in Boehm 1904

Himalayites cf. ***depressus*** Uhlig

1910 *Himalayites depressus* Uhlig: 148, pl. XL, figs 2a–c.

MATERIAL. One specimen, C.76669.

HORIZON. $2\frac{1}{2}$ feet above the base of the Chichali Formation in Mazari Tang section, Nizampur, Upper Tithonian.

DESCRIPTION. The specimen is evolute and roughly 56 mm in diameter. The whorl section is highly depressed, much wider than high with a broad flattish sulcate venter. Strong primary ribs end at large lateral tubercles, from which secondary ribs issue in bundles of 2 to 4, and pass onto the venter as sharp, high ribs. They are interrupted by the mid-ventral sulcus, and there are occasional small ventral tubercles (about 4 per half whorl) at each side of the sulcus.

REMARKS. In spite of the poor preservation the specimen resembles closely in whorl section and ornamentation Uhlig's holotype from the Spiti area, except for the occasional tubercles on some ribs near the ventral margin.

LOCALITY. Mazari Tang, Nizampur.

Himalayites middlemissi (Uhlig)

(Plate 9, figs 6a, b)

1910 *Hoplites* (*Blanfordia*) *middlemissi* Uhlig: 197, pl. XXXVII, figs 1a–c.

MATERIAL. One specimen, C.76668.

HORIZON. 10 feet below the base of the middle member of the Chichali Formation in the Trans Indus Ranges, Upper Tithonian.

DESCRIPTION. The specimen has a much depressed whorl section with a sulcate venter. The coarse primary ribs terminate near the middle of the whorl sides in large knob-like tubercles. From the tubercles bundles of 2 or 3 secondary ribs cross the venter with slight forward arching, and are interrupted at the mid-ventral sulcus. The whorl height is 22 mm, and the whorl thickness over the tubercles is 36·5 and 32 mm between the tubercles.

REMARKS. Uhlig (1910) placed the species, established by him from Lochambelkichak, Spiti area, in the genus *Blanfordia*. The prominent lateral tubercles, the depressed whorl section and trifurcating ribs on the outer whorl indicate generic affinities with *Himalayites*.

LOCALITY. Chichali Pass, Trans Indus Ranges.

Himalayites sp. indet.

MATERIAL. One specimen, C.76670.

HORIZON. 10 feet below the base of the middle member of the Chichali Formation, Upper Tithonian.

DESCRIPTION. This is a large wholly septate half whorl fragment of about 180 mm diameter. At the aperture the whorl height is 62 mm, the thickness about 70 mm. The whorl section is rounded at the apertural end but subquadrate at the smaller end, and the venter has a slight sulcus. The primary ribs are coarse, distant, slightly prorsiradiate and end at a large ventro-lateral tubercle. From the tubercles, 2 or 3 times as many secondary ribs cross the venter with slight forward arching, but fade along the mid-ventral line. There are smaller umbilical tubercles on the ribs.

REMARKS. This specimen is comparable with *Himalayites celebrans* (Uhlig 1910 : pl. XXXVI, figs 1a–c) from the Spiti area, in its whorl section, ventral view and partly in ornamentation, but differs in having longer primary ribs, with higher ventro-lateral tubercles and a smaller number of secondary ribs.

LOCALITY. Punnu Mines, Trans Indus Ranges.

Himalayites cf. *hyphaisis* (Blanford)

(Plate 9, figs 5a, b)

1863 *Ammonites hyphaisis* Blanford: 132, pl. IV, figs 2, 2a–b.
1910 *Himalayites hyphaisis* (Blanford); Uhlig: 149, pl. XXXVIII, figs 2a–b, 3–ad.
1910 *Himalayites* sp. nov. indet. Uhlig: 150, pl. XXXVIII, figs 5a–d.

MATERIAL. One specimen, C.76667.

HORIZON. 10 feet below the base of the middle member of the Chichali Formation, Upper Tithonian.

DESCRIPTION. A small, wholly septate half whorl fragment, with a subhexagonal whorl section, and grooved venter. The ribs are moderately distant, and fine simple ribs alternate with heavier ribs that bifurcate at a prominent mid-lateral tubercle.

All the ribs swell into radially elongated weak tubercles at the edge of the mid-ventral groove.

DIMENSIONS. C.76667–28·5: 11 (39), 11 (39), 10 (35).

REMARKS. The specimen compares favourably with *H. hyphasis* (Blanford) from Spiti, in ornamentation and whorl shape, but it differs in its less evolute shell, more prominent lateral tubercles, and more elevated whorl section. These differences may partly be due to the larger size of Uhlig's specimens (49 mm and 46·5 mm). In ribbing and prominent lateral tubercles, it is closer to *Himalayites* sp. nov. indet. (Uhlig, 1910 : 150) which in turn is closely allied to *H. hyphasis* (Blanford).

LOCALITY. South west of Malla Khel, Trans Indus Ranges.

Genus ***AULACOSPHINCTES*** Uhlig 1910

Aulacosqhinctes spitiensis (Uhlig)

(Plate 11, figs 2a, b, 3a, b)

1910 *Perisphinctes* (*Aulacosphinctes*) *spitiensis* Uhlig: 351, pl. XXXIII, figs 1a–c, 3a–c; pl.XLI, figs 1a–c.

Material. Two specimens, C.76686–7.

Horizon. About 2 feet below the base of the middle member of the Chichali Formation, Upper Tithonian.

Description. The larger specimen is evolute, moderately compressed, 72 mm in diameter, and part of the outer whorl is body-chamber. The whorl section is subquadrate, and the venter has a moderately deep groove. The ribs are straight and prorsiradiate, and commonly bifurcate on the upper part of the whorl side. Ribs that bifurcate twice are common on the outer whorl, but only occasional on the inner whorls. The first bifurcating point of these ribs is in the middle or the lower part of the whorl side. There are a few simple ribs, and rarely the ribs branch near the umbilical shoulder and one or both bifurcate again in the middle of the whorl side. The outer whorl has 42 ribs at 72 mm diameter. There are occasional shallow constrictions parallel to the ribs.

Dimensions. C.76687–72: 20 (28), 20·5 (28), 36 (50).

Remarks. These specimens are very similar in dimensions, rib density and multiple ribs to Uhlig's (1910) figured examples of *A. spitiensis* from the Himalayas. *Aulacosphinctes moerikeanus* (Oppel) is a very closely related species, also from the Himalayas (Uhlig, 1910 : 350, pl. XXXIII, fig. 2; pl. XXXVIII, fig. 6), which differs in being slightly more evolute and in having slightly fewer ribs.

Locality. South-west of Shaikh Budin, Shaikh Bud in Hills, Trans Indus Ranges.

APTYCHI

Laevaptychus

Material. Six fragments.

Horizon. 4 to 5 feet above the base of the Chichali Formation, Lower Kimmeridgian.

Description. The shell is moderately broad and thick, covered with fine pores on the convex side and concentric growth line or striae on the concave side (the inside).

Remarks. They are similar to the aptychus figured by Spath (1931: pl. LXXXVI) from the Katrol Beds of Cutch. In the Trans Indus Ranges they occur at the same horizon and locality as *Aspidoceras* (*Aspidoceras*) sp. indet.

Locality. Punnu Mines, Trans Indus Ranges.

VII. CORRELATIONS

a. Jurassic and Cretaceous stages in northern West Pakistan

The condensed nature of fossiliferous beds and the irregular distribution of ammonites in all the sections of northern West Pakistan do not warrant a detailed zonation. The zonal scheme (Fig. 6) adopted here is that of North West Europe for the Lower–Middle Jurassic (inclusive of the Callovian), Central and Southern Europe for the Upper Jurassic, and Western Europe for the Lower Cretaceous (Arkell and Wright 1957).

Jurassic

Lower Toarcian

The earliest marine fossiliferous Jurassic rocks are of Lower Toarcian age and contain a *Bouleiceras* fauna (including *B. nitiscens* Thevenin) which agrees well with that of Madagascar and Jebel Tuwaiq, Saudi Arabia (Arkell 1952, 1956).

Bajocian–Bathonian

No ammonites have been found in rocks of this age.

Callovian

The Callovian ammonites show a strong similarity with Cutch. The dominant genera are *Reineckeia, Obtusicostites, Hubertoceras, Choffatia.* The recognition of *Reineckeia anceps* in the assemblage places the beds in the Anceps Zone of the Middle Callovian.

No ammonites occur in the Lower Callovian beds and most of the Upper Callovian and Lower Oxfordian is missing from the area.

Upper Oxfordian

The Upper Oxfordian ammonites are again closely comparable with those of the "Upper Dhosa Oolite" and "Kantcote Sandstone" of Cutch (Spath 1933). The recognition in the assemblage of *Perisphinctes* (*Kranaosphinctes*) sp. indet., *Perisphinctes* (*Dichotomosphinctes*) cf. *rotoides* Ronchadze, and *Mayaites* cf. *waageni* (Uhlig), from the Trans Indus Ranges, and *Perisphinctes* (*Arisphinctes*) *orientalis* Siemiradzki and *Prososphinctes virguloides* (Waagen) from Kala Chitta–Nizampur area, places the assemblage in the Transversarium Zone. The higher Bimammatum Zone may also be presented in the highly condensed rubbly Upper Oxfordian beds (less than 2 feet thick) of northern West Pakistan. The ammonites are worn and indicate reworking. Spath (1934) placed the Kala Chitta fauna in the Transversarium Zone but pointed out that some species may belong to the Bimammatum Zone.

Lower Kimmeridgian

Above the Upper Oxfordian ammonite bed of the Chichali Formation in the Trans

Indus Range *Aspidoceras* (*Pseudowaagenia*) sp. indet. and *Physodoceras* (*Simaspidoceras*) sp. indet. occur. Five to ten feet above these beds are found *A.* (*Aspidoceras*) sp., *Laevaptychus, Pachysphinctes robustus* Spath and *Katroliceras* cf. *pottingeri* (J. de C. Sowerby) followed by *Ptychophylloceras ptychoicum* (Quenstedt) and *Hybonoticeras* sp. The assemblage indicates a Lower Kimmeridgian age. Associated with the ammonites are *Belemnopsis gerardi* (Oppel) which, though occurring in the underlying Upper Oxfordian rocks, does not extend into the overlying Lower Tithonian beds with *Aulacosphinctoides* and *Hildoglochiceras.*

Lower Tithonian

About 5 feet above the higher Kimmeridgian bed *Aulacosphinctoides* (including *A. uhligi* Spath), *Hildoglochiceras* sp. indet. (comparable with *H. kobelli*), *Virgatosphinctes* (*V. frequens, V. densiplicatus*) and *Provalanginites* gen. nov. occur followed higher up by *Proniceras indicum* Spath and *Holcophylloceras silesiacum* (Oppel). The first appearance of *Aulacosphinctoides* is taken here as marking of the base of the Tithonian, but the placing of the faunas in the detailed zonal scheme of Arkell (1957) is not yet possible because of the rare occurrence of these genera, uneven distribution in the area and condensed nature of the deposits.

Upper Tithonian

In the Upper Tithonian the commonly occurring genus is *Blanfordiceras* (including *B. wallichi*). The first appearance of *Blanfordiceras* in the area is taken to mark the boundary between the Lower and Upper Tithonian. *Blanfordiceras* is associated higher up with *Himalayites* and *Aulacosphinctes.*

Immediately below the *Subthurmannia* beds (considered here to mark the base of the Cretaceous) *Protacanthodiscus* aff. *michaelis* (Uhlig), *Protacanthodiscus* sp. indet., *Spiticeras multiforme* Djanelidze, *Spiticeras* sp. indet. occur. This assemblage suggests the highest Tithonian (Chaperi Zone).

The Upper Tithonian beds of the Chichali Formation have abundant *Hibolithes* (also abundant in the Lower Tithonian and Kimmeridgian) but are not very rich in ammonites.

Jurassic–Cretaceous Boundary

The Cretaceous boundary is drawn at the first appearance of *Subthurmannia* (including *S. fermori*) in the upper part of the Lower member of the Chichali Formation. The Jurassic–Cretaceous boundary is transitional in most areas, except in parts of Hazara, where non-sequences are present in the succession.

Lower Cretaceous

Berriasian

Subthurmania is the most abundant genus, associated with *Neocosmoceras* (*N.* aff. *spitiensis*) and *Negreliceras.* The assemblage is typically Berriasian and indicates the Boissieri Zone.

The ammonites of Berriasian age are also present in the western part of the Main Salt Range, though they are less abundantly developed. This is in contrast to Spath's suggestion (presumably based on failure of collections) that they are absent from the Salt Range (1939 : 131). In Hazara and Kala Chitta Range their occurrence is rare, and in parts of Hazara they are missing because of non-sequence.

Valanginian

The Valanginian ammonites, though condensed in beds 15 to 20 feet thick and missing in parts of Kala Chitta and Hazara (because of a non-sequence), include three faunal assemblages in the Trans Indus Ranges and Western Kohat. These are (from top to bottom) as follows:—

3. *Olcostephanus* (*Olcostephanus*) *salinarius* Zone, including many species of *O.* (*Olcostephanus*), less commonly *O.* (*Rogersites*), *Distoloceras*, *Lyticoceras* and *Leopoldia*.
2. *Neocomites* (*Odontodiscoceras*) *similis* Zone, including species of *Neocomites* (*Parandiceras*) such as *N.* (*P.*) *theodorii* (Oppel), *Kilianella* (*K. asiatica* Spath, *K. leptosma* Uhlig, *Kilianella* sp. nov.), *Neocomites* (*Calliptychoceras*) and *Neohoploceras*.
1. *Sarasinella uhligi* Zone. This is a provisional poorly defined zone and includes *Sarasinella subspinosa* (Uhlig), *Thurmanniceras* sp. *Neocomites* (*Neocomites*) sp. nov.

The *Sarasinella uhligi* Zone seems to correspond to the unnamed zone below the Roubaudiana Zone of Wright (1957) or to Gratianopolitense Zone of Spath (1939 : 132).

The *Neocomites* (*Odontodiscoceras*) *similis* Zone is equivalent to the *Kilianella roubaudiana* Zone of Wright and Spath.

The highest *Olcostephanus* (*O.*) *salinarius* Zone corresponds to the Schenki and Verrucosum Zones of Spath (1939). The dominant genus in this zone is *Olcostephanus* (*Olcostephanus*) which is associated with *O.* (*Rogersites*), *Distoloceras*, *Leopoldia* and *Lyticoceras*.

b. Correlations within Pakistan

(i) *Baluchistan*

In Baluchistan ammonites of Lower (Toarcian and doubtful Sinemurian), Middle (Upper Bathonian–Lower Callovian) and Upper Jurassic (Lower Tithonian) age have been recorded (Noetling 1897; Vredenburg 1909; Spath 1933, 1936; Arkell 1956). The main similarities between the ammonite faunas are found in the Lower Toarcian and Tithonian.

The *Bouleiceras* species are similar, but the other recorded Lower Jurassic ammonite genera from Baluchistan do not occur in the Lower Toarcian ammonite bed of Kala Chitta and Hazara. The associated rhynchonellids and *Pecten* sp., however, are closely comparable. A detailed study of the Lower Jurassic sequence

SYSTEM.	SERIES.	STAGES.	STANDARD OF THE L… NORTH W… JURASSIC ARKELL 1957 CRETACEO… WRIGHT 1957 (…956)	SPITI. (AFTER ARKELL 1956, PASCOE 1959)		CUTCH. (AFTER SPATH 1933, CALLOMAN 1955 AND ARKELL 1956).		NORTHERN PAKISTAN.
CRETACEOUS	LOWER (IN PART).	BARREMIAN		No ammonites (Flysch)	Giumal Sandstone			No ammonites
		HAUTERIVIAN	…ria					
		VALANGINIAN		Rogersites schenki, Olcostephanus maidani, Bochianites, Kilianella, Neocomites, Sarasinella, Thurmanniceras (Not zoned)	Upper Spiti Shale	Trigonia cressa, Trigonia ventricosa		Olcostephanus (O.) salinarius with O. (Rogersites), Lyticoceras, Distaloceras; Neocomites (Odontodiscoceras) similis with Kilianella, N. (Calliptychoceras), Bochianites, N. (Parandiceras), Sarasinella, N. (Neocomites) copei, Thurmanniceras (Lower part not zoned)
		BERRIASIAN		Subthurmannia boissieri, Neocosmoceras, Spiticeras (Not zoned)		No evidence (Unfossiliferous)		Subthurmannia fermori with many S. spp., Spiticeras (Spiticeras), S. (Negreliceras), Neocosmoceras, Protocanthodiscus
JURASSIC	UPPER	TITHONIAN		Blanfordiceras, Aulacosphinctes	Upper Spiti Shale	Aulacosphinctes, Micracanthoceras (Not zoned)	Umia Ammonite Bed	Protocanthodiscus, Aulacosphinctes, Himalayites, Blanfordiceras
				Kossmatia	Middle Spiti Shale	Virgatosphinctes		Proniceras indicum, Holcophylloceras (Not zoned)
				Virgatosphinctes, Hildoglochiceras, Aulacosphinctoides (Not zoned)		Hildoglochiceras	Upper Katrol Shale	Aulacosphinctoides, Virgatosphinctes, Hildoglochiceras (Not zoned)
						Aulacosphinctoides	Upper Katrol Sandstone	
		KIMMERIDGIAN	…is	B. gerardi, B. uhligi, "Perisphinctes" bipticatus (Not zoned)	Lower Spiti Shale	Pachysphinctes, Aspidoceras, Hybonoticeras, Katroliceras, Torquatisphinctes, Streblites, Taramelliceras (Not zoned), Oichotomosphinctes, Discosphinctes	Lr. & Mid. Katrol Sst.	Hybonoticeras, Ptychophylloceras ptycholcum; Pachysphinctes, Katroliceras, Aspidoceras; Simaspidoceras, P. (Pseudowaagenia,) B. gerardi
		OXFORDIAN		Mayaites (Grayiceras), M. (Epimayites), B. gerardi		Mayaites, Perisphinctes	Kantcole Sst.	P. (Oichotomosphinctes), P. (Arisphinctes); P. (Kranaosphinctes), Euaspidoceras, M. (Grayiceras)
		CALLOVIAN	…)	? Represented locally	Belemnopsis sulcacutus Beds	Ochetoceras (Camphylites), Peltoceratides	Dhosa oolite	No evidence (Missing)
						A. lamberti		
			…as			Peltoceras athleta	Upper / Lower	Rinecanceps, Obtusicostites, Huberteceras, Kinkeliniceras
						Reineckeia anceps, Reineckeia rehmani	Chari group	
				Macrocephalites		Indocephalites diadematus		? No ammonites; Reported Indocephalites by Spath, 1933
						Macrocephalites dimerus, M. triangularis	Patcham Grp.	
	MIDDLE	BATHONIAN		?	Laptol Series (= Upper Kioto Limestone)	Corbula lyrata, Protocardia, Stephanoceratid	Kuar Bet Beds	Corbula lyrata, P. grandidieri
		BAJOCIAN		?				
	LOWER (part)	TOARCIAN		Aloclytoceras				Boulelceras

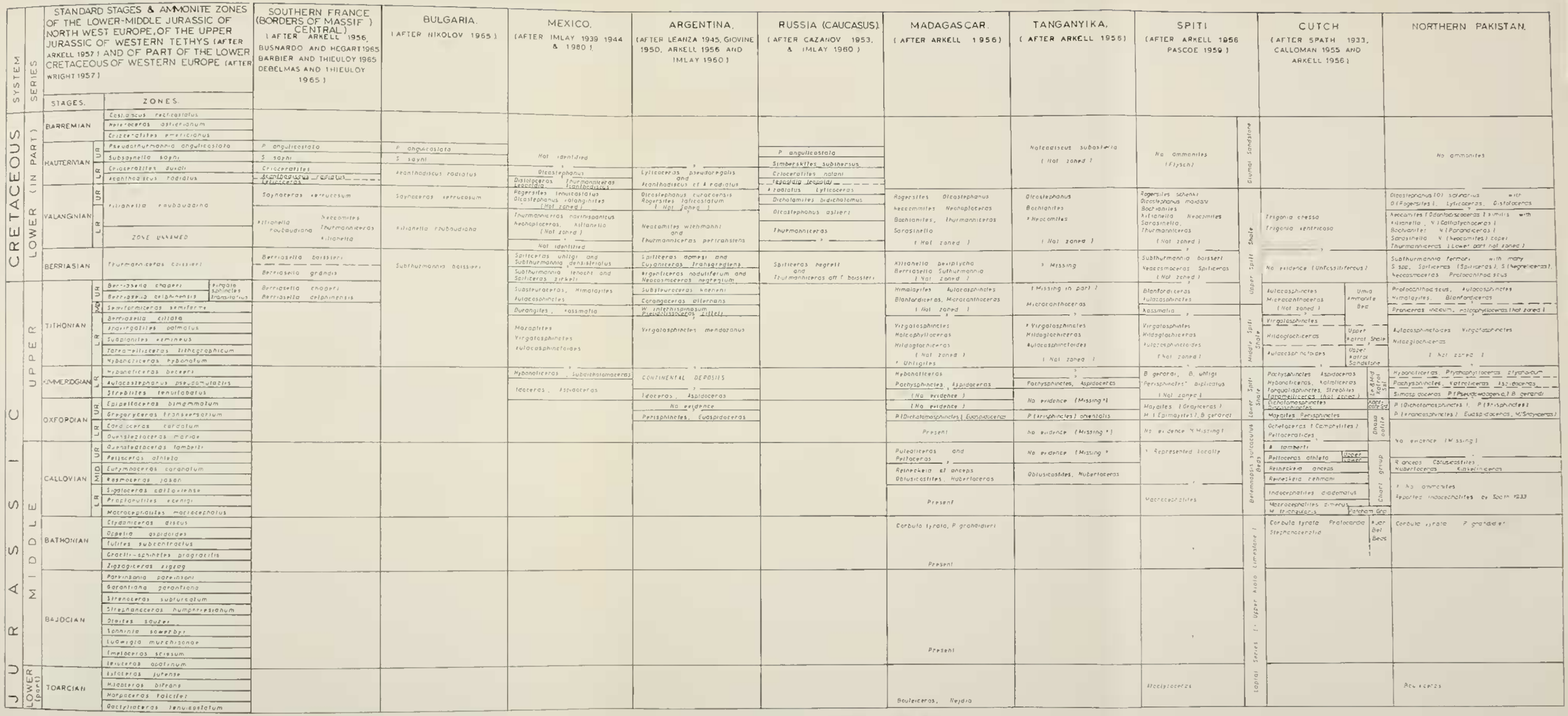

FIG. 6. Correlation of Jurassic and Lower Cretaceous faunas of northern West Pakistan.

of Baluchistan should prove of great interest in comparing the supposed Upper Pliensbachian age of the *Bouleiceras* in Spain by Bizon *et al.* (1966), as the sequence in Baluchistan is believed to extend below the Toarcian.

The *Virgatosphinctes* species, *V. denseplicatus* (Waagen) compare well with the *Virgatosphinctes* species, found associated with *Aulacosphinctoides* in Hazara and the Trans Indus Ranges.

The ?Berriasian or Valanginian "Belemnite shales" (Arkell 1956 : 396) apparently succeed Lower Callovian limestone with *Macrocephalites*, and have *Hibolithes* (*H. pistilliformis* and *H. subfusiformis*), which have also been recorded by Spath (1939) from the Salt Range and Trans Indus Ranges. Stevens (1965 : 150), reviewing the belemnites of the Salt Range, confirmed Spath's identification of *H. pistilliformis* and *H. subfusiformis*, but has suggested that "It is likely that the belemnites recorded by Spath from this locality, and all *Belemnopsis* recorded by him from the Salt Range, have been derived from the underlying Upper Jurassic horizon, the belemnite in place being *Hibolithes*". Spath (1939), however, described *Hibolithes* (*H. pistilliformis* and *H. subfusiformis*) associated with the less commonly occurring *Belemnopsis* from Trans Indus and Salt Ranges.

The present investigations indicate that *Hibolithes* occurs in association with *Belemnopsis* and other Upper Jurassic ammonites, and none of the assemblage appears derived. In the major part of the Tithonian *Hibolithes* occurs without association of *Belemnopsis*, but lower down the two species of *Hibolithes* are associated with less commonly *Belemnopsis*. Forms resembling *H. pistilliformis* and *H. subfusiformis* continue in the Berriasian and Valanginian, but are not so well preserved as those in the Kimmeridgian and Lower Tithonian beds of the Chichali Formation ("Belemnite Beds" of Spath). In fact the preservation of the *Hibolithes* monographed by Spath, suggests that they are mostly from the Tithonian and Kimmeridgian beds of the "Belemnite shales" of the Trans Indus and Salt Range. These observations suggest that *H. pistilliformis* and *H. subfusiformis* are either long ranging (Upper Jurassic to Lower Cretaceous) or their identification as such from the Salt Range and the Trans Indus Ranges needs more careful examination. A long range for these species seems to be a more logical conclusion. Their presence in Baluchistan in the "Belemnite shales" may not restrict the age of these beds to Berriasian or Valanginian, but in all probability the "Belemnite shales" of Baluchistan range in age from Tithonian to Neocomian, for Lower Tithonian is indicated by the presence of *Virgatosphinctes* in certain areas of Baluchistan.

c. Correlations with areas outside Pakistan

(i) *Cutch*

The Middle and Upper Jurassic faunas of Cutch show close similarity with those of northern West Pakistan, particularly those of Trans Indus and Kala Chitta Ranges (Fig. 6). The Jurassic and Lower Cretaceous succession of Cutch has been summarized by Spath (1933) and Arkell (1956).

The Upper Bathonian bivalves fauna of Kuar Bet Beds of Cutch can be correlated

with a similar fauna from the uppermost beds of the Samana Suk Limestone in Kala Chitta (fig. 6). The faunas of the Macrocephalus and Rehmanni Zones have not been found by the present survey. There is a suggestion of the presence of the Rehmanni Zone in the *Subkossmatia flemingi* Bed north of Kalabagh (reported by Spath 1933, but not found by the present survey), and the *Belemnopsis grantana* Bed of Western Kohat (uppermost part of the Samana Suk Limestone). These faunas suggest that the uppermost part of the Samana Suk Limestone in these areas may be slightly older than the Anceps fauna of the rest of the Trans Indus Ranges (west of Chichali Pass).

The Anceps Zone of Cutch is well represented in commonly occurring genera and species in the uppermost 2 feet of the Samana Suk Limestone of the Trans Indus Ranges (west of Chichali Pass). The major part of the Athleta Zone and Lower Oxfordian are missing from northern West Pakistan. The Upper Dhosa Oolite (Transversarium Zone) and Kancote Sandstone (Bimammatum Zone) faunas may be correlated with a similar assemblage in the condensed bed (less than 2 feet) at the base of the Chichali Formation in the Trans Indus Ranges and the Kala Chitta–Nizampur areas.

The ammonite faunas of the Lower and Middle Katrol Beds compare favourably with those found in the Trans Indus Ranges, except that not all the genera occurring in Cutch (such as *Taramelliceras, Glochiceras, Streblites*) have been found in Pakistan. These Lower–Middle Katrol Beds have been doubtfully placed by Spath and Arkell in the Middle Kimmeridgian, though both authors have pointed out the presence of Pseudomutabilis and Upper Tenuilobatus Zones in the assemblage.

In the Trans Indus Range it was found that *Aulacosphinctoides* occurs a few feet above the *Pachysphinctes, Katroliceras* and *Hybonoticeras* Beds, and the lowest Kimmeridgian beds have *A.* (*Pseudowaagenia*) and *P.* (*Simaspidoceras*), and no *Pachysphinctes*. These two Kimmeridgian horizons are comparable with the Middle and Lower Katrol Beds of Cutch.

The placing of Lower and Middle Katrol Beds in the Middle Kimmeridgian by Spath (1933) and Arkell (1956) presumably was based on the identification of *Hybnoticeras beckeri* in the Lower Katrol Beds. The other elements of the fauna point to a Lower Kimmeridgian age of the assemblage. In Europe and parts of Africa *Pachysphinctes, Taramelliceras, Torquatisphinctes* and *Katroliceras* have been more typically reported from the Lower Kimmeridgian rather than from the *H. beckeri* Zone. In the Tellian Atlas *Streblites tenuilobatus* occurs in association with *Hybonoticeras* (Arkell 1956 : 273). It is, therefore, likely that the genus *Hybonoticeras* may have appeared earlier in the Kimmeridgian in Cutch and the Trans Indus Ranges, and very likely it does not represent the true Beckeri Zone.

It is interesting to note that more definite evidence of the occurrence of *Aulacosphinctoides* is reported from the next higher horizon, the Upper Katrol Sandstone, which is over 700 feet thick and in main is unfossiliferous. The Trans Indus Kimmeridgian and Tithonian Beds on the other hand are much condensed, but even there a slight unfossiliferous interval occurs between the *Pachysphinctes* Beds and the overlying *Aulacosphinctoides* Beds. It is suggested that the time interval represented by the true Beckeri Zone may be present in the unfossiliferous Upper

Katrol Sandstone of Cutch or the beds above the *Pachysphinctes* horizon in the Trans Indus Ranges.

The Upper Katrol Sandstone, Upper Katrol Shales and the lower part of Umia Ammonite Bed, can be correlated with the Lower Tithonian Beds of the Trans Indus Range and Hazara. There are, however, some differences: in Cutch *Aulacosphinctoides* is reported from the Upper Katrol Shales which has *Hildoglochiceras* and other faunas; it is doubtfully and rarely recorded from the Umia Ammonite Bed which has more typically a good representation of *Virgatosphinctes*.

In the Trans Indus Ranges and especially in Hazara, *Aulacosphinctoides* and *Virgatosphinctes* occur in close association. *Hildoglochiceras* has been found associated with *Aulacosphinctoides* in the Trans Indus Ranges.

In northern West Pakistan the appearance of *Aulacosphinctoides* has proved to be a useful and convenient horizon to mark the base of the Lower Tithonian. The Upper Tithonian/Lower Tithonian boundary is placed at the appearance of *Blanfordiceras*, followed by *Himalayites* and *Aulacosphinctes*. From the Umia Ammonite Bed of Cutch, there is no record of *Himalayites* and *Blanfordiceras* (common in Spiti, Pakistan and Madagascar), but *Aulacosphinctes* is reported, which suggests that part of the Umia Ammonite Bed is Upper Tithonian.

(ii) *Spiti*

The Upper Jurassic, Berriasian and Valanginian faunas of the Spiti Shales (thickness 500 feet) compare favourably with northern West Pakistan (fig. 6). The ammonites were monographed by Uhlig (1903–10) who defined the stratigraphic position of some within the three-fold division of the Spiti shales. Other faunas were placed undefined in the Spiti shales, but many of these are considered by Pascoe (1959 : 1174) to have been collected from the Chidamu Beds (Middle Spiti Shales). The succession is described by Diener (1895), Hayden (1904), Uhlig (1910), Arkell (1956) and Pascoe (1959).

Giumal sandstone (up to 495 ft). This formation is regarded as Middle Neocomian by Arkell (1956) and post Valanginian by Pascoe (1959).

Spiti shales (500 ft), consisting of the following three divisions: Upper Spiti shales (Lochambel Beds), with *Olcostephanus* (*Olcostephanus*), *O.* (*Rogersites*), *Neocomites* (*Calliptychoceras*), *N.* (*Parandiceras*), *N.* (*Odontodiscoceras*), *Kilianella*, *Neocomites*, *Sarasinella*, *Thurmanniceras*, *Subthurmannia*, *Neocosmoceras*, *Spiticeras*, *Blanfordiceras*, *Himalayites* and *Aulacosphinctes*.

Middle Spiti shales. A number of Upper Tithonian and Lower Neocomian genera have been doubtfully listed from these beds (Pascoe 1959 : 1174–75). In addition, more definite forms reported include *Blandforiceras*, *Pterolytoceras exoticum*, *Paraboliceras*, *Kossmatia* and *Uhligites*. This assemblage suggests that at least part of the Middle Spiti Shales is Upper Tithonian. Other ammonites from the Middle Spiti Shales include *Virgatosphinctes*, *Aulacosphinctoides* and *Hildoglochiceras* (stratigraphical position unknown), and *Belemnopsis uhligi* Stevens (=*B. gerardi* of Uhlig).

Lower Spiti shales (Belemnopsis gerardi Beds), with *Belemnopsis gerardi* (Stevens 1965, p. 149 doubts its identification), *Mayaites*, *Grayiceras* and *Epimayites*.

The Lower Spiti shales are regarded as Upper Oxfordian by Uhlig (1910), Spath (1933, 1939), Arkell (1956), Pascoe (1959) and Krishnan (1960), but Stevens (1965 : 149) on the basis of identification of *B. uhligi* (=*B. gerardi* of Uhlig) considers them to be Middle Kimmeridgian. In the present correlation, on the basis of the mayaitid ammonites, these are regarded as Upper Oxfordian to Lower Kimmeridgian.

The Lower Spiti shales can be broadly correlated with the lowest bed of the Chichali Formation of the Trans Indus Range, the basal 2 to 3 feet condensed bed of the Chichali Formation of Kala Chitta and Nizampur areas, and with the whole of the Chichali Formation ("Spiti Shale" facies) of Kalapani–Kathwal sections of Hazara. In Hazara there is no evidence of Upper Oxfordian beds, and it is likely also that in parts of Spiti the Upper Oxfordian mayaitid beds may not have been deposited, and the whole of the Lower Spiti Shales may be Lower Kimmeridgian in age.

The ammonites faunas of the Middle Spiti shales (Chidamu Beds) compare well with those of northern West Pakistan, except that such genera as *Kossmatia* and *Paraboliceras* are not known from Pakistan. The *Aulacosphinctoides* and *Virgatosphinctes* compare closely with those found in the Trans Indus Ranges, Budin Hills and Hazara. In Hazara these two genera occur in the lower part of the "Giumal sandstone" (Lumshiwal Formation) and are not found in the "Spiti shale" facies of the Chichali Formation of the Kathwal–Kalapani sections. This correlation requires caution, for in the vast outcrop of the Spiti shales in the Himalayas the fauna may not be restricted to the same lithological division of the Spiti shales. This presumably accounts for the Lower Tithonian–Valanginian fauna listed by Pascoe (1959 : 1174), who believed most of them to have come mainly from the Middle Spiti shales. It is, therefore, probable that the three divisions of Spiti shales in the Spiti area may be diachronous as in Hazara.

The Upper Spiti shales have a very interesting assemblage which is of upper Tithonian to Valanginian age. The Upper Tithonian can be correlated with a similar fauna from northern West Pakistan, except that *Protacanthodiscus* seems to be not represented in the Spiti shales. The Jurassic/Cretaceous boundary occurs within the Upper Spiti shales without a break similar to that of the Trans Indus Ranges. The Berriasian is indicated by *Subthurmannia boissieri* and *S. surgharensis*. The more common occurrence of *Neocosmoceras* and *Spiticeras* as compared to *Subthurmannia* in Spiti, is contrasted with the abundance of *Subthurmannia* in the Berriasian of the Trans Indus Ranges.

The three Valanginian zones of the Trans Indus Ranges (*O. salinarius*, *N. similis* and *S. uhligi*) are represented in the Valanginian assemblages of the Spiti shales.

The overlying Giumal Sandstone can be broadly correlated with the Lumshiwal Formation of Kala Chitta, with the Upper member of the Chichali Formation, and the Lumshiwal Formation of Western Kohat and the Trans Indus Ranges. In Pakistan, Aptian and Albian ammonites occur, but apparently no ammonites are reported from the "Giumal sandstone" of Spiti.

(iii) *Persia* (*Elburz Mountains*)

In the Elburz Mountains marine succession from Toarcian to Lower Cretaceous is developed, and the Lower and Middle Jurassic rocks have many ammonite horizons. There appears to be a faunal break between the Middle Callovian and Upper Oxfordian, and the Toarcian marine rocks overlie the rest of the continental Lower Jurassic (Arkell 1956).

The *Reineckeia* Beds of Persia (with *R. anceps*) are comparable with those of the Trans Indus Ranges, except that in Persia genera like *Obtusicostites*, *Hubertoceras* have not been reported.

The perisphinctid fauna and associated *Euaspidoceras* of Upper Oxfordian age compare well with that of the Trans Indus Ranges and Kala Chitta.

There is hardly any similarity with the Kimmeridgian faunas, but from the Tithonian *Virgatosphinctes*, *Berriasella* and *Substeueroceras* have been recorded which show the presence of Lower and Upper Tithonian (Spath 1933 : 831).

On the Lower Cretaceous Spath (1939 : 141) commented, "There is only one small suite, submitted to me . . . . which showed a remarkable similarity even in the preservation, to the fauna of the Valanginian marls of the south of France". He further remarked, "there is abundant evidence of the presence of forms like *Berriasella*, *Substeuroceras* and allies in southern and south western Persia and of a complete succession from the uppermost Jurassic into the Lower Cretaceous".

(iv) *Saudi Arabia* (*Jebel Tuwaiq*)

The Jurassic and Cretaceous sequence in Saudi Arabia (Powers, Remirez, Redmond and Elberg 1966) indicates disconformities between Triassic and Lower Toarcian, between Middle Callovian and Oxfordian and within the Lower and Upper Cretaceous which are comparable with Northern Pakistan.

Ammonites are recorded from Toarcian, Middle–Upper Bajocean, Middle Bathonian, Middle Callovian and there is a small perisphinctid assemblage from Oxfordian (Transversarium Zone) and Kimmeridgian (Tenuilobatus Zone). The Jurassic/Lower Cretaceous boundary is considered transitional.

A firm correlation exists with the Lower Toarcian *Bouleiceras* Beds (Marrat Formation) of Jebel Tuwaiq (Arkell 1956 : 300).

(v) *Iraq* (*Kurdistan*)

An interesting Upper Jurassic assemblage was described by Spath (1950) from Kurdistan. The lowest Upper Jurassic fauna (Arkell 1956 : 376) is placed in the Lower Kimmeridgian (Pseudomutabilis Zone) and has the genera *Ataxioceras* and *Aulacostephanus* which are not found in northern West Pakistan.

The next fossiliferous beds (with *Pseudolissoceras*) are separated from the underlying Lower Kimmeridgian by 39 meters of unfossiliferous sediments. The fauna of the *Pseudolissoceras* Beds includes *Pseudolissoceras*, *Proniceras*, *Phanerostephanus* and ?*Glochiceras*, and was placed into the Middle Tithonian by Spath. He (1950 :

100–101) doubtfully assigned two specimens to *Glochiceras*, though one was closely compared with *Hildoglochieras grossicostatum* Imlay, and the other has a pronounced mid-lateral groove and is more evolute than a typical *Glochiceras*. The presence of *Proniceras* in the assemblage suggests its correlation with the *Proniceras indicum* Bed of the Trans Indus Ranges, where it occurs above the *Aulacosphinctoides* and *Virgatosphinctes* horizon. The latter two genera are not known from Kurdistan and it appears that this zone will occupy a position in the 39 meters of unfossiliferous sediments below the *Pseudolissoceras* Beds. The fauna of the Lower Tithonian (lower part) thus seems to be missing from Kurdistan.

The ammonites of higher beds are placed in the Upper Tithonian which include *Substeueroceras*, *Berriasella* and *Paradontoceras*, and can be broadly correlated on the basis of *Berriasella* with northern West Pakistan.

Spath (1950) mentioned that the fauna of the Boissieri Zone of the Lower Cretaceous is present in Kurdistan and thus the Jurassic–Cretaceous boundary appears transitional.

(vi) *Madagascar*

In the northern areas of Madagascar a more complete Jurassic–Lower Cretaceous sequence is developed and the Jurassic–Cretaceous boundary is transitional (Thevenin 1906, 1908; Besairie 1932, 1936, 1946; Collignon 1949; Arkell 1956) Firm correlations with northern West Pakistan can be made in the Lower Toarcian, Upper Bathonian, Middle Callovian, Upper Oxfordian, Lower Kimmeridgian, Tithonian, Berriasian and Valanginian (fig. 6). The rest of the Jurassic ammonite sequence is better developed and more complete in Madagascar than in northern West Pakistan.

The earliest marine Jurassic fauna reported from Madagascar is dated as Lower Toarcian on the basis of *Bouleiceras*, which is associated with *Protogrammoceras*, *Nejdia*, *Speriferina rostrata* and *Pecten*. These beds can be correlated with the *Bouleiceras* Beds of the Datta Formation in Kala Chitta and Hazara.

The next strata that can be correlated are the Upper Bathonian Bivalve Beds of Madagascar with *Corbula lyrate* and *Protocardia grandidieri* also found in the uppermost beds of the Samana Suk Limestone in Kala Chitta.

From the Middle Callovian of Northern and Southern Madagascar, *Obtusicostites*, *Hubertoceras*, *Reineckeia* cf. *anceps* and other ammonite genera have been recorded (Arkell 1956 : 340). This assemblage compares well with that of the Trans Indus Ranges, except that other associated ammonite genera are lacking in northern West Pakistan.

In the Upper Oxfordian of Madagascar a *P.* (*Dichotomosphinctes*) and *Euaspidoceras* fauna of the Transversarium Zone is present, but the higher Bimammatum Zone is believed to be absent. These faunas are comparable with the Upper Oxfordian faunas of the Trans Indus Ranges and Kala Chitta.

The Lower Kimmeridgian succession in Madagascar is probably incomplete, extending to the Pseudomutabilis Zone. The lowest Tenuilobatus Zone is believed to be absent. The fauna includes *Aspidoceras*, *Pachysphinctes*, *Lithacoceras*,

Torquatisphinctes and *Taramelliceras*. *Aspidoceras* and *Pachysphinctes* are comparable with the similar forms found in the Lower Kimmerdigian succession of the Trans Indus Ranges.

The Tithonian of Madagascar again has some common faunal elements. In the Lower Tithonian *Virgatosphinctes* occurs quite commonly and is associated with *Holcophylloceras*, *Hildoglochiceras kobelli* (Oppel), and other ammonites. This associated is comparable with northern West Pakistan where, *Aulacosphinctoides* also occurs. Apparently no *Aulacosphinctoides* are known from Madagascar.

The Upper Tithonian Beds of Madagascar, with *Aulacosphinctes*, *Blanfordiceras acuticosta* Uhlig and *Himalayites*, can be correlated with a similar assemblage in northern West Pakistan. It is interesting to note that *Blanfordiceras* and *Himalayites* are shared by Madagascar, Northern Pakistan and Spiti, but are not known from Cutch where only *Aulacosphinctes* is reported. The genus *Micracanthoceras* reported from the Upper Tithonian of Madagascar is not known from northern West Pakistan or Spiti.

The Upper Tithonian clays and marls pass into the overlying Neocomian Beds in Madagascar. In the Berriasian Spath (1939 : 137) has listed *Subthurmannia*, which was previously identified as *Berriasella* by Besairie, and associated with this is *Kilianella*. In Pakistan *Kilianella* occurs commonly associated with *Neocomites* rather than *Subthurmannia*.

From the *Rogersites* Beds of Madagascar Spath (1930 : 138) has listed a number of genera and species which are similar to the Valanginian beds of the Chichali Formation of the Trans Indus Ranges. These include *Thurmanniceras*, *Sarasinella*, *Neocomites*, *Neohoploceras*, *Bochianites*, *Olcostephanus* (*Olcostephanus*), *O.* (*Rogersites*), *Distoloceras* and ?*Leopoldia*. *O.* (*Rogersites*) is more abundantly distributed in Madagascar than *O.* (*Olcostephanus*), while in the Trans Indus Ranges *O.* (*Olcostephanus*) occurs more abundantly than *O.* (*Rogersites*). The association of these two genera with *Distoloceras* and *Leopoldia* is very closely comparable with Northern Pakistan.

Neolissoceras grasianum (d'Orbigny), though listed from the Valanginian beds of Madagascar, was found to occur both in the Berriasian and Valanginian beds of the Trans Indus Ranges. The genus *Subthurmannia* is also not so well represented in Madagascar.

(vii) *Tanganyika*

The Middle Callovian and Upper Jurassic fauna of Kilwa–Kiswere Lindi Hinterland (Arkell 1956 : 331) show strong similarity with parts of northern Pakistan. The common genera in the Callovian are *Obtusicostites*, *Hubertoceras* and *Choffatia*. The upper Oxfordian has perisphinctids, myaitids and *Euaspidoceras*.

Dietrich (1925) and Arkell (1956) placed the Kimmeridgian ammonites from the Septarian marls in the Mutabilis and/or Pseudomutabilis Zones (Lower Kimmeridgian). The assemblage includes some common genera such as *Pachysphinctes*, *Aspidoceras* and *Ptychophylloceras*, but others, such as *Streblites*, *Glochiceras*, *Taramelliceras* (known from the Middle and Lower Katrol Sandstone of Cutch) and

Nebrodites (not recorded from Cutch), are not known from Northern Pakistan. On the basis of *Pachysphinctes* and *Aspidoceras*, the Trans Indus Kimmeridgian beds can be correlated with that of Tanganyika.

The *Virgatosphinctes* fauna of the Smeei Beds is comparable with a similar fauna from Northern Pakistan, except that no *Aulacosphinctoides* is reported from the Kiswere–Lindi Hinterland. In the Tendaguru area, however, the Smeei Beds (Arkell 1956 : 335) have yielded *Holcophylloceras*, *Hildoglochiceras* and *Subdichotomoceras*, which compares well with the Upper Katrol *Hildoglochiceras* Beds of Cutch. At a lower level (*Nerinella* Bed), *Haploceras*, ?*Pachysphinctes staffi* (generic affinities strongly doubted by Spath 1933, who regarded it an *Aulacosphinctoides*) and *Subdichotomoceras sparsiplicatum* (Waagen) occur. It appears that the doubtful *Aulacosphinctoides* of the *Nerinella* Beds of Tendaguru occur below the *Hildoglochiceras* Beds, and occupy a position similar to the Upper Katrol Sandstone of Cutch with *Aulacosphinctoides*. In northern Pakistan, *Aulacosphinctoides* is associated with *Hildoglochiceras* and *Virgatosphinctes* and may thus indicate a rather condensed Lower Tithonian sequence in Pakistan.

From the *Trigonia schwartzi* Beds of Tendaguru, which disconformably succeed the Jurassic rocks, *Olcostephanus*, *Bochianites* and a doubtful *Neocomites* are recorded (Spath 1930 : 140) and these compare with similar Valanginian fauna from Pakistan.

(viii) *Jubaland*

Although rocks of Lower Jurassic, Kimmeridgian and Cretaceous ages are known from Jubaland (Arkell 1956 : 317), the best correlation is established with the Lower Toarcian *Bouleiceras* Beds of Didimtu Hill, which overlie, with intervening conglomeratic or gritty beds, the metamorphic basement complex.

The Upper Oxfordian fragmentary perisphinctid (*Kranaosphinctes*), *Dhosaites* and *Euaspidoceras* assemblage can be correlated with that of the Kala Chitta Range.

(ix) *Somaliland*

The Lower Toarcian *Bouleiceras* Beds and the Lower–Middle Kimmeridgian formations of Somaliland are comparable with northern West Pakistan. In the Tithonian a different ammonite assemblage (*Anavirgatites* and *Pseudoinvoluticeras*) is developed (Arkell 1956 : 309). The Kimmeridgian Daghani Shale underlies Tithonian Gawan Limestone and has *Streblites*, *Subdichotomoceras*, *Torquatisphinctes*, *Idoceras* and *Hybonoticeras* in the upper part. Lower down *Idoceras*, *Sutneria*, *Aspidoceras* and *Aptychus latus* occur.

(x) *Southern France* (*borders of the Massif Central*)

The Upper Jurassic (Tithonian) and Lower Neocomian ammonite faunas of the classic areas of Berrias show close similarity in genera and some similarity in species with northern West Pakistan (fig. 6). There are, however, discrepancies which raise correlation problems.

In the type section of the Upper Tithonian (Ardeche), Neumayr (1871) proposed *Virgatosphinctes* (? an *Aulacosphinctes*) *transitorius* (Oppel) as the zonal index of the Upper Tithonian. Mazenot (1939) used two other indices, *Berriasella chaperi* (Pictet) above and *B. delphinensis* (Kilian) below, with the associated fauna of *Corongoceras, Micracanthoceras, Proniceras* and *Spiticeras* particularly well developed near Chomerac. Some of the *Berriasella* species of the Upper Tithonian, including *B. chaperi*, are more closely related to *Protacanthodiscus* because of their development of tubercles. The genera shared between Pakistan and France, are *Proracanthodiscus* and *Spiticeras*. The two zones of Mazenot may thus correspond to the *Protacanthodiscus, Himalayites, Spiticeras* fauna above and the *Blanfordiceras* fauna below.

Proniceras indicum Spath, the only species known from Pakistan, occurs lower down in the sequence, and similarly a number of *Virgatosphinctes* species known from Pakistan occur associated with *Aulacosphinctoides* in the Lower Tithonian. The occurrence of *Proniceras* in France seems to be higher in the Tithonian.

The ammonite succession of the classic type area of Berrias was summarized by Hegart (1965) and Busnardo and Hegart (1965). The dominant Berriasian genus in France is *Berriasella*, while in the Trans Indus Ranges it is *Subthurmannia*. This discrepancy seems to be partly due to non-recognition of the genera *Protacanthodiscus* and *Subthurmannia* by the French authors. A number of species listed by Mazenot (1939) and others under *Berriasella* (*chaperi, malbosi, paramimouna, aspers* etc) seem to be closely related to *Protacanthodiscus*. Similarly *boissieri* has been placed in *Berriasella*, though American and British palaeontologists have put it in *Subthurmannia*. *Boisseri* is closely related to the type species of *Subthurmannia*, (*S. fermori* Spath), and its inclusion in *Subthurmannia* is preferred here.

A comparison with the frequency and range of Tithonian–Berriasian–Valanginian ammonite genera and species in France given by Busnardo and Hegart (1965 : 27, Table VI) leads to the following conclusions:

1. The genus *Berriasella*, though starting in the Lower Tithonian, has a maximum development in the Berriasian and dies out about the beginning of Valanginian. In the Berriasian of northern West Pakistan, *Subthurmannia* is abundantly distributed and only one doubtful *Berriasella* species is recognized.
2. Busnardo and Hegart have shown that *Himalayites* extends from the Upper Tithonian to fairly high in the Berriasian (in Arkell and Wright 1957, the genus is treated as Tithonian). In Pakistan no species of *Himalayites* were found associated with a typical Berriasian assemblage. The genus occurs below the *Subthurmannia* Beds in horizons which have yielded *Protacanthodiscus* and even *Blanfordiceras* and *Spiticeras*, suggesting it to be a good indicator of Upper Tithonian in Pakistan.
3. The range of *Spiticeras* is from the Upper Tithonian to about the middle of the Lower Valanginian, with a maximum development in the Berriasian. In Pakistan *Spiticeras* and *Negreliceras* occur with *Subthurmannia* and *Neocosmoceras* in the Berriasian. It is not found in the Valanginian, and only a few species occur in the Upper Tithonian. *Spiticeras multiforme* Djanelidze,

reported by Hegart (1965) from Boisseri Zone, occurs in the Trans Indus Range 3 feet below the *Subthurmannia* Beds at a horizon which indicates uppermost Tithonian.

4. The range and maximum development of *Thurmanniceras* in the Lower Valanginian is closely comparable with Pakistan.
5. The range and distribution of *Neocosmoceras* in the Berriasian of France is similar to Pakistan.
6. The distribution of *Kilianella* is again comparable with Pakistan except that its occurrence is somewhat higher in the Lower Valanginian of Pakistan.
7. In France, Busnardo and Hegart have shown that the genus *Neocomites* extends from almost the base of the Upper Tithonian to the Valanginian and probably higher. If this is the range of *Neocomites* sensu stricto, it seems to be long ranging in France. No true *Neocomites* (*Neocomites*) has been found in Pakistan below the *Subthurmannia* beds, or in the *Olcostephanus* beds of the Upper Valanginian. It is more typical of the Lower Valanginian of Northern Pakistan.
8. *Olcostephanus* has been shown by the French authors start in the Lower Valanginian, and show a maximum development in the Upper Valanginian and Hauterivian. In Pakistan *O.* (*Olcostephanus*) occurs more abundantly and *O.* (*Rogersites*) less abundantly in the Upper Valanginian condensed beds, and is much less frequently associated with *Leopoldia*, *Lyticoceras*, and *Distoloceras*. The *Olcostephanus* species includes comparable forms like *O.* (*R.*) *atherstoni* (reported from the Upper Valanginian and Lower Hautervian of France) and *O.* (*O.*) *filosus* Baumberger (reported from the Lower Hauterivian of France). Thus there appears to be overlap of the lower zone of Lower Hauterivian of France with the *O.* (*O.*) *salinarius* zone of the present author from the Upper Valanginian of Pakistan. The lower Hauterivian of France, in contrast to Pakistan, shows abundance of *Leopoldia*, *Lyticoceras*, and *Acanthodiscus*. The *Olcostephanus* Beds of Pakistan show rare occurrence of *Leopoldia*, *Lyticoceras* and *Distoloceras* (Upper Valanginian–Hauterivian genera), and thus are regarded here as Upper Valanginian.

To conclude, the Berriasian and Valanginian ammonite faunas of France have many affinities with the faunas of northern West Pakistan, but the range of many genera in France and the association of some do not tally with the noted sequence in Pakistan. No doubt the succession in France is more complete and the fauna is rich in number of species and specimens.

The zone of *B. grandis* is difficult to correlate with the succession in Pakistan where the base of *Subthurmania* has been found to be a convenient and logical horizon to place the base of Cretaceous, and this (Fermori Zone) corresponds well with the Boisseri Zone of France. In a comparable position to the Grandis Zone, *Himalayites hypaisis* (Blanford), *Himalayites* sp., *Protacanthodiscus* spp., *S. multiforme*, *Aulacosphinctes* sp., have been found. If this assemblage is put in the Grandis Zone, the Tithonian and Cretaceous boundary becomes vague and undeterminable

in the continuous glauconitic sandy Upper Tithonian–Berriasian sequence of Pakistan.

The present author thus considers the base of the *S. boisseri* (or *S. fermori*) as a most suitable place to draw the Cretaceous–Jurassic boundary, as this zone has been recognized by Imlay (1961) in Mexico, Leanza (1945) in South America, Cazanov (1953) in Russia and has been discussed in more detail by Casey (1963).

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